DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

INSTITUTE OF THE AERONAUTICAL SCIENCES

# AERO/SPACE ENGINEERING

REVIEW OF CURRENT AND FUTURE TRENDS IN AIRCRAFT • MISSILES • ROCKETS • SATELLITES • SPACECRAFT

## The Cone-Sphere in Hypersonic Helium Above Mach 20

## Prophecy for Propulsion

One Man's Guess

## Flight Testing Experiments with the TILT-WING AIRCRAFT

## The Space Age Effect on Management

## Thin Doublers for Fatigue-Resistant Aluminum-Alloy Structures

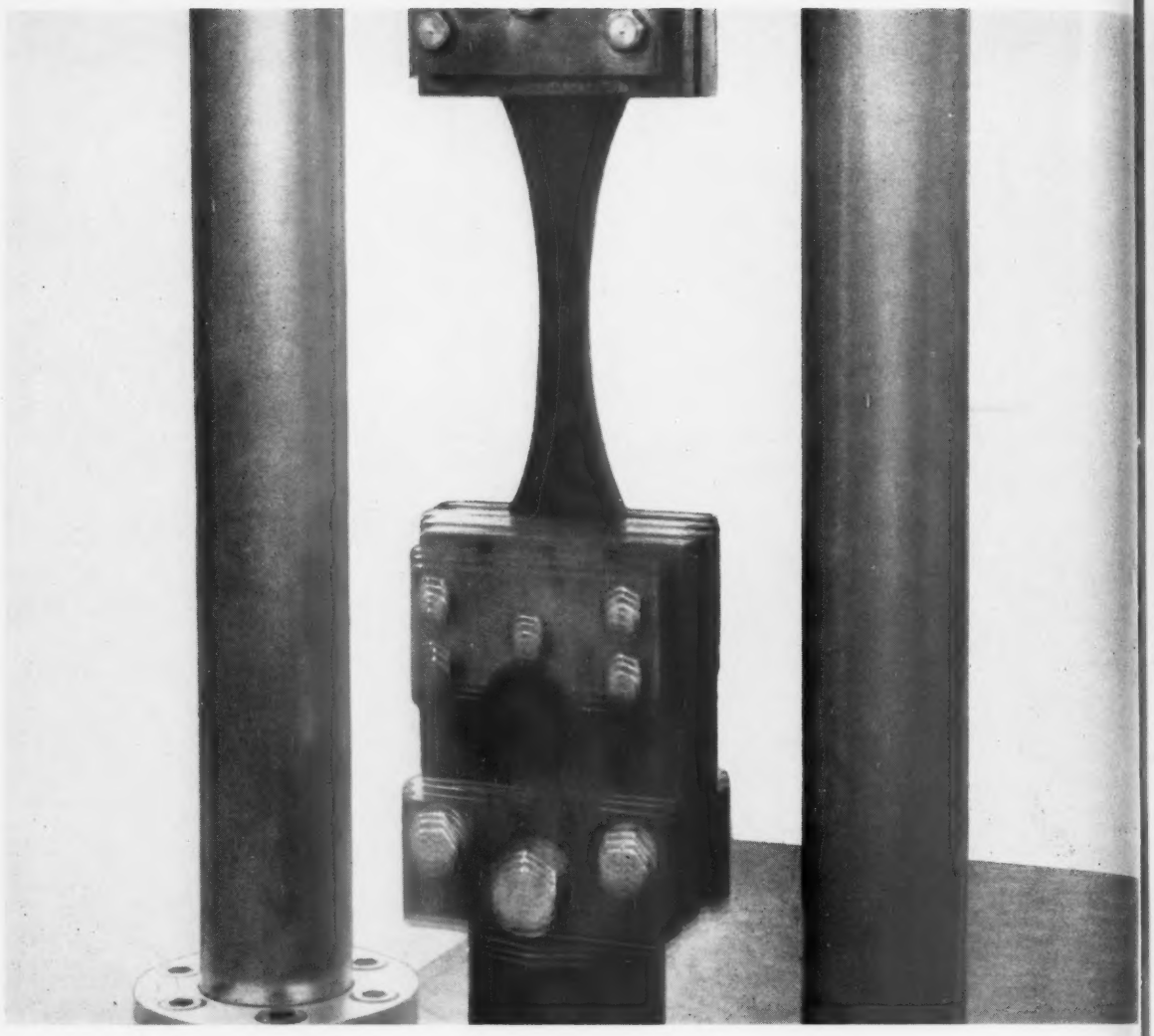
## Potentialities and Problems of Nuclear Rocket Propulsion

## Man-Machine Integration in Space Vehicles

In this issue
Rocket Pioneer First Winner of Louis W. Hill Space Transportation Award

FEBRUARY | 1959
First Papers From 27th IAS Annual Meeting

XUM



# Stressing the importance of reliability!

Through the ultimate in design data provided by our Reliability Group, Rohr Engineers are able to design the greatest efficiency, dependability, and economy into Rohr-built aircraft components.

Working with every modern test device (such as the fatigue testing machine shown above) Rohr reliability men chart thousands of stress spectrums and other data to predict the safe life of given materials at given stress loads.

Reliability is another reason Rohr is widely known as the
WORLD'S LARGEST PRODUCER OF COMPONENTS FOR FLIGHT

ROHR
AIRCRAFT CORPORATION

MAIN PLANT AND HEADQUARTERS: CHULA VISTA, CALIF.; PLANT: RIVERSIDE, CALIF.; ASSEMBLY PLANTS: WINDER, GA.; AUBURN, WASH.

XUM

Huge rocket case furnaces



Complete design facilities for development or production



Steel—or fiber-glass—rocket cases for weight-savings



Quality control—by X Ray, hydrostatic and complete metallurgical test equipment

Thrust axis engineered to watchmaker's precision

10-year experience harnesses the high specific impulse of newest solid propellants

# Foresight with a wallop!

Foresight which saw the coming of the Space-and-Missile Age enabled Goodyear Aircraft Corporation to begin construction—*more than ten years ago*—of what is today one of the most advanced and largest integrated rocket engine case facilities in the nation.

Furnaces—among the largest ever built for the task—spawn these exacting space-conquering units. Experienced technicians, backed by batteries of test equipment, control the quality of the materials—insure the soundness of each weld—maintain tolerances to thousandths of an inch.

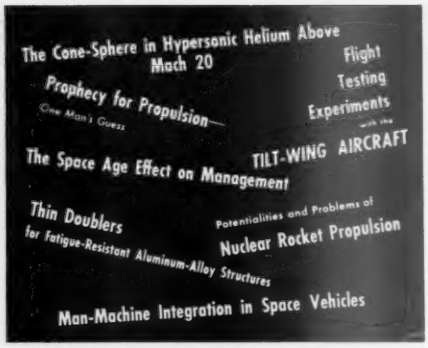
This foresight, these skills, this equipment have made Goodyear Aircraft the birthplace of more large-size rocket engine cases than any other producer.

*For more information* on this completely integrated facility, write Goodyear Aircraft Corporation, Dept. 916 FB, Akron 15, Ohio.

**ROCKET ENGINE CASES**—One of the Prime Capabilities of

**GOODYEAR AIRCRAFT**

*Plants in Akron, Ohio, and Litchfield Park, Arizona*




## Our Cover . . .

*. . . represents a milestone in efforts of Aero/Space Engineering to give its readers the latest technical information as quickly as possible. The illustration is composed of the titles of several papers presented at the IAS 27th Annual Meeting in New York and published exclusively herein within a few days of actual delivery. This could not, of course, have been accomplished without the cooperation of and, in some cases, additional work by the authors, to whom we are especially grateful.*—ED.


## PUBLICATION STAFF

*Publisher:* Welman A. Shrader

*Editor:* Allan Bernhardt

*Managing Editor:* Rita J. Turino

*Reviews Editor:* Irene W. Bogolubsky

*Book Reviews Editor:* John J. Glennon

*Editorial Assistant:* Helen S. Goldman

*Technical Advisers:*
W. R. Sears, Robert R. Dexter, S. Paul Johnston

*Business Staff:*
*Advertising Manager:* Joseph P. Ryan
*Western Representative:* John Ball, Jr.
*Business & Production Manager:* Hugh C. Judge
*Assistant Production Mgr.:* D. C. Lombardi



## EDITORIAL ADVISORY COMMITTEES

### Space Technology

Rear Adm. Rawson Bennett, USN
Major Gen. Otis O. Benson, Jr., USAF(MC)
Milton Clauser
Major Gen. Marvin Demler, USAF
Krafft A. Ehricke
Brig. Gen. H. F. Gregory, USAF
Major Gen. J. B. Medaris, USA
Capt. Alfred B. Metsger, USN
Courtland Perkins
E. R. Piore
H. Guyford Stever
Hubertus Strughold, M.D.
Herbert York

### Specialties

Robert J. Benford, M.D.
Melvin N. Gough
Jerome Lederer

### Design, Structures, & Materials

A. Francis Arcier
Wellwood E. Beall
William B. Bergen
Fred N. Dickerman
Robert L. Hall
Edward H. Heinemann
Harold D. Hoekstra
C. L. Johnson
Alexander Kartveli
Kendall Perkins
Richard L. Schleicher
Edgar Schmued
Igor I. Sikorsky
Ernest G. Stout
Kirby F. Thornton
Walter Tydon

### Electronics

K. C. Black
Bruce G. Eaton, Jr.
Richard B. Hubbard
David S. Little
Frank Mansur
John Margosian
P. C. Sandretto

### Flight Propulsion

George W. Brady
Dimitrius Gerdan
Leonard S. Hobbs
R. P. Kroon
Everard M. Lester
W. G. Lundquist
Abe Silverstein
Philip B. Taylor
E. S. Thompson
Raymond W. Young

### Instruments

Preston R. Bassett
Victor E. Carbonara
Charles H. Colvin
Frank R. Cook
Richard M. Mock
Walter H. Skidmore
R. C. Sylvander

### Air Transport & Operations

Charles Froesch
J. A. Herlihy
John C. Leslie
William Littlewood
R. W. Rummel
R. Dixon Speas



AERO/SPACE ENGINEERING

. . . formerly *Aeronautical Engineering Review*, is published monthly by the Institute of the Aeronautical Sciences, Inc., at 20th and Northampton Streets, Easton, Pa. Headquarters and Editorial Offices: 2 East 64th Street, New York 21, N.Y. (TEmpleton 8-3800). Western Office: 7660 Beverly Blvd., Los Angeles 36, Calif.

Subscription rates: United States and possessions, 1 year, $5.00; single copies, $0.50. Foreign countries including Canada (American currency rates), 1 year, $6.00; single copies, $0.50.

Second-class mail privileges authorized at Easton, Pa. Acceptance for mailing at a special rate of postage as provided for in the Act of August 24, 1912.

Notices of change of address should be sent to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y., at least 30 days prior to actual change of address.



© Copyright 1959 by the Institute of the Aeronautical Sciences, Inc.


Statements and opinions expressed in *Aero/Space Engineering* are to be understood as individual expressions and not those of the Institute.

formerly
AERONAUTICAL ENGINEERING REVIEW

# AERO/SPACE ENGINEERING

VOLUME 18 / NUMBER 2 February 1959

## Featured in this issue

*A New Feature* **5** Letters to the Editor
*All readers are invited to voice their opinions—technical or otherwise.*

*A Report* **15** Dynamics-Aeroelasticity Specialists Meeting
*Highlights of the Texas Conference—one of the outstanding IAS meetings of the year.*

*Editorial* **20** Appropriate Award
*The first Louis W. Hill Space Transportation Award posthumously granted to Dr. Robert H. Goddard.*

*A Special Insert* **21** The First Louis W. Hill Space Transportation Award
*Includes a tribute to Dr. Robert H. Goddard reprinted from a 1950 issue of Aeronautica, a former IAS publication.*

*Edward A. Ledeen*
Curtiss-Wright Corporation
**29** The Space Age Effect on Management
*Increased complexity is defined as one problem requiring solution—but there are many others.*

*Robert H. Johnson*
General Electric Company
**30** The Cone-Sphere in Hypersonic Helium Above Mach 20
*Presenting the geometric relation between detached shock waves and a series of cone-sphere bodies of varying bluntness.*

*T. F. Dixon*
North American Aviation, Inc.
**35** Prophecy for Propulsion—One Man's Guess
*A single-barrel, liquid-propellant rocket engine of a million pounds of thrust can be operational by 1965.*

*C. R. Smith*
Convair
**40** Thin Doublers for Fatigue-Resistant Aluminum-Alloy Structures
*The future may bring a state in the art of designing fatigue-resistant structures where fatigue will not be a problem.*

*W. Z. Stepniewski and Paul J. Dancik*
Vertol Aircraft Corporation
**43** Flight Testing Experiments With the Tilt-Wing Aircraft
*Experience confirms that small flight research aircraft can prove—quickly and cheaply—the basic feasibility of a new concept.*

*T. P. Cotter*
University of California
**50** Potentialities and Problems of Nuclear Rocket Propulsion
*A reactor producing useful thrust is awaited with much eagerness; there are two areas of possible superiority.*

*Comdr. George W. Hoover, USN*
Department of the Navy
**54** Man-Machine Integration in Space Vehicles
*"Let's not just build a ship with adequate performance capabilities and then . . . remember we must have personnel to operate it."*

## Departments

**9** IAS News Notes
**13** IAS News
**19** Dateline World
**60** Meet the Staff
**73** Reviews
**94** IAS Reports
**95** International Abstracts
**117** Books
**121** IAS Corporate Members
**123** Personnel Opportunities
**125** Index to Advertisers
**127** New Products and Literature

# GENERAL MOTORS HEXES HEAT ON THE VOODOO!

Harrison aircraft oil coolers—another quality product of General Motors research.

**HARRISON OIL COOLERS CONTROL VITAL TEMPERATURES ON McDONNELL F-101B VOODOO—POWERFUL NEW INTERCEPTOR!**

Like magic, the new Voodoo F-101B streaks to its target with an amazing combination of speed and long range. Such outstanding performance demands dependable operating temperatures *every second*. That's why rugged and reliable Harrison heat exchangers were selected to cool the engine oil on this supersonic all-weather interceptor of the Air Defense Command. Built and backed by General Motors, Harrison heat-transfer equipment provides dependable temperature control—in every type of industry, every line of defense. Harrison, with over 47 years in the heat-exchanger field, is your assurance of top quality in product and performance. If you have a cooling problem, look to Harrison for the answer.

GM HARRISON

TEMPERATURES MADE TO ORDER

AIRCRAFT, AUTOMOTIVE, MARINE AND INDUSTRIAL HEAT EXCHANGERS

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK

# LETTERS to the Editor

## Views Us and the News

■ Your changes in AERONAUTICAL ENGINEERING REVIEW to AERO/SPACE ENGINEERING have been followed with interest. In general they appear satisfactory and in keeping with changing times. I have the impression, however, that News of Member and Section activities are losing coverage. I hope this impression is wrong and that your editorial policy will include maintaining good Section and Member activity reporting in their interest, thus keeping the magazine as a part of the membership.

In reading issues of the recent past, it appeared to me that Member and Section news items were reduced to a bare minimum and fitted in after other space was allotted. News items on Section meetings were printed several months after the meeting. I realize that you can only print news as available. If the delays or lack of information are the results of reporting, then possibly the Section Secretaries should be encouraged to report more completely and more promptly. Activities of the various Sections are of interest both for what others are doing, as well as for source information for program ideas.

The articles printed each month are interesting and timely. I suggest that one of the articles printed each month could be the best paper presented the previous month at a Section meeting. This could generate competition obviously, but more important, it gives opportunity of broad recognition of the many Section officers working to put on good programs.

**G. L. Desmond**
**5020 Newport Avenue**
**Washington, D.C.**

✦ ✦ ✦

## A Plea for Students, Educators

■ Your announcement concerning the addition of a "Letters" feature to AERO/SPACE ENGINEERING indicates that the IAS is alert to opportunities providing needed services to its members. The writer wishes to make a few comments concerning a topic which may be of general interest, and which is of particular interest to student members of the IAS and engineering educators. These remarks deal with the increasing problems facing aeronautical engineering departments due to the lack of professional prestige and backing available to other branches or departments of engineering through membership in their professional organizations.

These comments are not in the form of criticism, but serious problems do exist and some high-level thinking and planning will be required to solve them. Among the more pressing issues are lack of membership in the Engineers' Council for Professional Development, need for representation on a national level, formulation of policies by persons who have had no training in aeronautical engineering, and the general lack of backing on issues of vital importance to aeronautical engineers. Since the IAS is not a professional organization devoted to the interests of any particular branch of engineering, aeronautical engineering departments find themselves without any source of professional backing other than their own efforts. Student branches are assisted greatly by the IAS but the whole emphasis is on a general situation applying to many branches of engineering. Nearly all fields of engineering other than aeronautical have a strong national organization behind them, to speak for them on a national basis and serve their best interests.

Engineering educators in the field of aeronautical engineering have struggled with these problems for many years. Success in solving them has not been good. Some have proposed that another society should be organized on lines similar to those of the older professional groups. Others think that time will tend to solve some of the more pressing problems. Perhaps the IAS should devote more space in AERO/SPACE ENGINEERING to bringing some of these problems out into the open so that more people can contribute to constructive approaches toward solutions. The writer feels that both students and educators need help from all available sources, and the IAS could furnish leadership and guidance where it is desperately needed.

**Colgan H. Bryan**
**Head, Dept. of Aeronautical Engineering**
**College of Engineering**
**University of Alabama**

*The IAS applied for membership in ECPD about 2 years ago.*—ED.

✦ ✦ ✦

## The "How" in Better Education

■ I thoroughly enjoyed Professor Terman's article, "Observations on Engineering Education," which appeared in the December issue. There are a few comments I would like to offer concerning ways in which the engineering education can be improved.

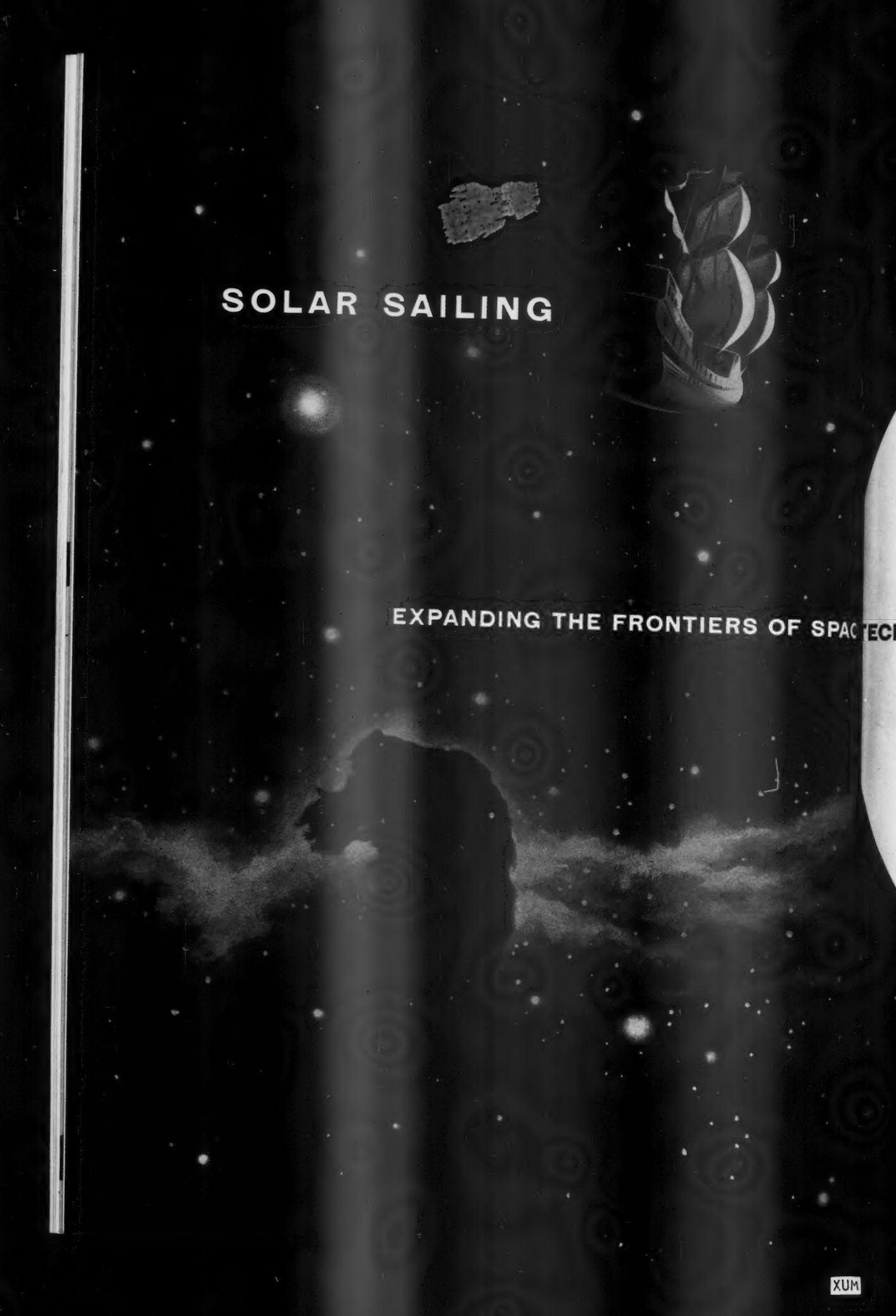
Professor Terman is in favor of raising admission standards of our universities. I would like to suggest how this may be done while, at the same time, providing a richer high school education. Currently, the engineering education is being uncomfortably forced into 4 years, leaving many courses on the undergraduate level available only to those who pursue an advanced degree. A look at the freshman engineering curriculum of many of our schools reveals courses such as *Engineering Drawing*, *Descriptive Geometry*, *Analytic Geometry*, and *College Algebra* which can successfully be initiated into the high school senior year program for pre-engineering students. These courses would then serve as prerequisites for admission into an engineering school. This would serve a dual purpose. First, it would give both the student and the university a better idea of the student's chances of succeeding in his pursual of an engineering degree. Second, it would provide room for more advanced courses, which presently have to be deleted from the program due to lack of space.

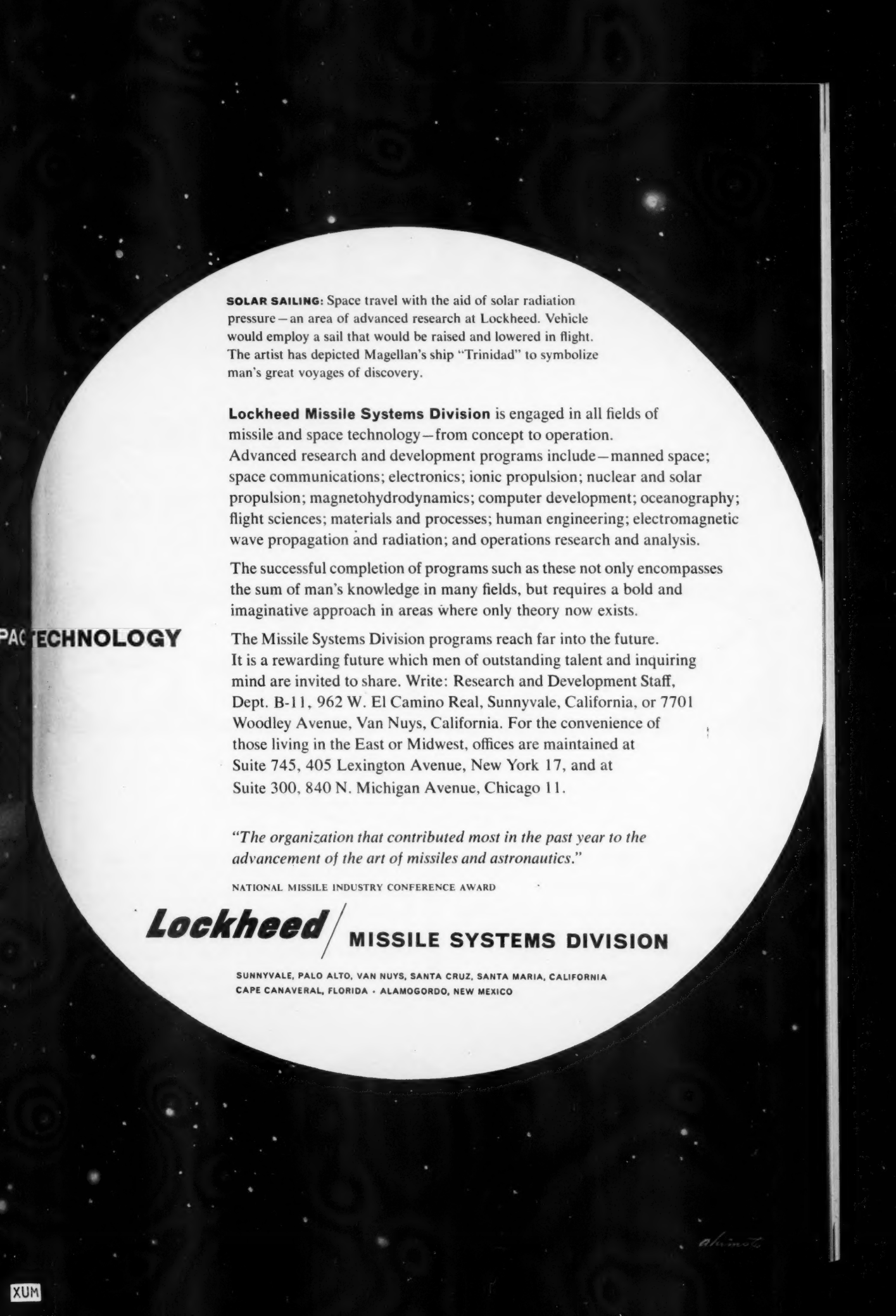
It is also my contention that a great number of our universities are in dire need of revising their undergraduate curricula if they hope to successfully prepare a youngster for our space-age society. Industry is making tremendously rapid strides in the field of aeronautics while our educational institutions are moving at a snail's pace. Many of our engineering schools do not offer degrees in Aeronautical Engineering, much less one in Astronautics. Even in those schools that do have Aeronautical Engineering Departments, the courses taught are of the nature of *Aircraft Internal Combustion Engines*, *Machine Design*, *Instrumentation Laboratory*, and other "practical" courses. An up-to-date curriculum would definitely substitute for these "practical" courses ones in *Advanced Calculus*, *Theoretical Mechanics*, *Kinetic Theory of Gases*, etc. An increased theoretical background would provide the student with the capability of attacking more diversified problems. Once in industry, he can adapt his theoretical knowledge to existing practical problems, and he is in a better position to successfully solve new problems as they arise.

By adopting a progressive attitude and keeping pace with industry, our universities will produce more versatile and creative engineering.

**Barry Hyman**
**Structural Engineer, Missile Div.**
**McDonnell Aircraft Corp.**

**The Editors welcome letters from readers, although none can be acknowledged. All must be signed, but identities will be withheld on request.**


SOLAR SAILING
EXPANDING THE FRONTIERS OF SPAC
TECH
XUM



**SOLAR SAILING:** Space travel with the aid of solar radiation pressure—an area of advanced research at Lockheed. Vehicle would employ a sail that would be raised and lowered in flight. The artist has depicted Magellan's ship "Trinidad" to symbolize man's great voyages of discovery.

**Lockheed Missile Systems Division** is engaged in all fields of missile and space technology—from concept to operation. Advanced research and development programs include—manned space; space communications; electronics; ionic propulsion; nuclear and solar propulsion; magnetohydrodynamics; computer development; oceanography; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation; and operations research and analysis.

The successful completion of programs such as these not only encompasses the sum of man's knowledge in many fields, but requires a bold and imaginative approach in areas where only theory now exists.

PAC TECHNOLOGY

The Missile Systems Division programs reach far into the future. It is a rewarding future which men of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. B-11, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Avenue, Van Nuys, California. For the convenience of those living in the East or Midwest, offices are maintained at Suite 745, 405 Lexington Avenue, New York 17, and at Suite 300, 840 N. Michigan Avenue, Chicago 11.

*"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics."*

NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

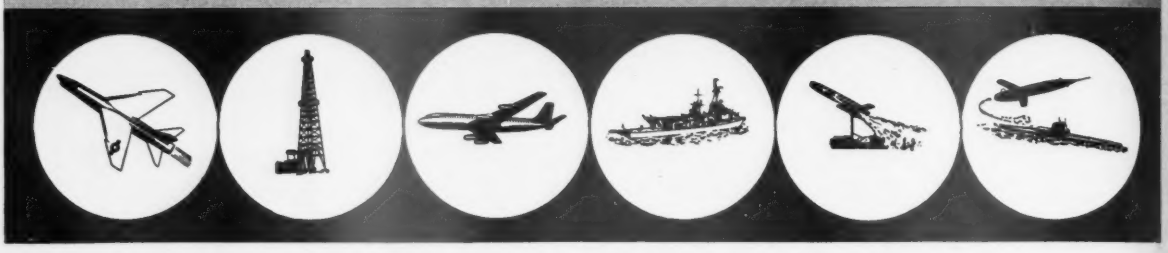
**Lockheed** / **MISSILE SYSTEMS DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA · ALAMOGORDO, NEW MEXICO

XUM

# SARGENT

## SERVO-SYSTEMS OF FORCE CONTROL



With 38 years acceptance Sargent builds precision linear and rotary hydraulic, pneumatic, mechanical and electronic systems of force control to meet successfully the increasingly high requirements of marine, aircraft, missile, petroleum and industrial use. From original idea to finished product – SARGENT.

**SARGENT FACILITIES**
Research
Design
Development
Testing
Qualifying

Manufacturing including –
Machining & Grinding
Heat Treating, all types
Plating, all types
Inspection
Assembly

**SARGENT BUILDS**
Servo-Systems
Hydraulic Systems
Integrated Packages
Hydraulic Actuators
Hydraulic Valves

Hydraulic Pumps
Hydraulic Motors
Pneumatic Cylinders
Pneumatic Valves
Ball Screw Actuators
Gear Actuators
Gear Accessory Boxes
Electronic Systems

*Standard of Excellence*

Sargent
QUALITY BUILDS GOOD WILL

*Since 1920*

**ENGINEERING CORPORATION**

MAIN OFFICE & PLANT, 2533 E. FIFTY-SIXTH ST.
HUNTINGTON PARK, CALIF.

*"GOOD WILL" is the disposition of the pleased customer to return to the place where he has been well treated.*
*– U.S. Supreme Court*




XUM

IAS News Notes

February, 1959

## IAS AWARDS-HONORS ANNOUNCED;

## 12 NAMED TO TERMS ON COUNCIL

The Institute's highest honor -- election of Honorary Fellows -- has been conferred for 1958 on Charles S. Draper, Head, Department of Aeronautics and Astronautics, MIT, and Sir George Edwards, Managing Director, Vickers Armstrongs (Aircraft), Ltd., England. These, and other IAS honors and awards, together with identities of 12 elected to Council posts for 1959, were announced at the IAS 27th Annual Meeting in New York City, which concluded on January 29.

The following were elected Fellows: A. M. Ballantyne, Secretary, The Royal Aeronautical Society, England; Ralph L. Bayless, Chief Engineer, Convair (San Diego), Division of General Dynamics Corp.; Dean R. Chapman, Aeronautical Research Scientist, Ames Research Center, NASA; R. R. Gilruth, Assistant Director, Langley Research Center, NASA; Henry Gortler, Director, Institute of Mathematics, University of Freiburg, Germany; R. Greinacher, Section Chief, Service Technique Militaire, Switzerland; Simon Ramo, Executive Vice President, Thompson Ramo Wooldridge, Inc.; Homer J. Stewart, Director, Office of Progress Planning and Evaluation, NASA; Charles Tilgner, Jr., Chief Aeronautical Engineer, Grumman Aircraft Engineering Corp.; Karl D. Wood, Professor of Aeronautical Engineering, University of Colorado.

The First Louis W. Hill Space Transportation Award was presented posthumously to Robert H. Goddard (1882-1945), visionary rocket propulsion pioneer. (Details on pages 20-28.) Other awards announced were: John J. Jeffries Award to Hubertus Strughold, M.D., Prof. of Space Medicine and Advisor for Research, School of Aviation Medicine, USAF; Robert M. Losey Award to Patrick D. McTaggart-Cowan, Associate Director, Canadian Meteorological Service, Toronto; Sylvanus A. Reed Award to Victor E. Carbonara, President, Kollsman Instrument Corp.; Lawrence A. Sperry Award to Robert G. Loewy, Chief Technical Engineer, Vertol Aircraft Corp.

Minta Martin Aeronautical Student Fund National Paper Awards went to Joseph Tsu Chieh Liu, University of Michigan, (Graduate Division), for the paper, "The Laminar Boundary Layer Flow on Axis Symmetric Body and Transverse Curvature Effect." The Undergraduate Division Award went to Robert H. Tolson, Virginia Polytechnic Institute, for the paper, "Longitudinal Stability Derivatives of Missile Shaped Bodies at Hypersonic Speeds."

Newly-elected members of the Institute Council are: (Three-year terms) L. Eugene Root, Lockheed Aircraft Corp., Missile Systems Division; William R. Sears, Director, Graduate School of Engineering, Cornell University; Milton U. Clauser, Vice President and Director, Physical Research Laboratory, Space Technology Laboratories; H. Guyford Stever, Professor of Aeronautical Engineering and Associate Dean of Engineering, MIT; George F. Douglas, Vice President--Engineering, Northrop Division, Northrop Aircraft, Inc. Elected for a two-year term was R. Dixon Speas, President, R. Dixon Speas Associates. To serve one-year terms as representatives of specific areas in the U. S. are: Clifford E. Roberts, Washington Representative, Boeing Airplane Co. and Theodore E. Beck, Manager of Engineering, Fairchild Aircraft Division, (Eastern Area); Paul H. Dane, Colonel,

USAF, Prof. of Thermodynamics, U. S. Air Force Academy and Milford F. Vanik, Chief of Technical Staff, Engineering, Wichita Division, Boeing Airplane Co. (Central Area). Dean R. Chapman, Aeronautical Research Scientist, Ames Research Center, NASA, and M.C. Haddon, Director--Marketing, California Division, Lockheed Aircraft Corp. (Western Area). Election of 1959 IAS officers was announced in the January issue on page 13.

THE 15TH ANNUAL NATIONAL FORUM of the American Helicopter Society will be held May 6-9 at the Sheraton Park Hotel, Washington, D. C. More details are available from Miss Jean Ross Howard, Forum Chairman, Helicopter Council, Aircraft Industries Association, Washington, D. C.

## SECTION MEETINGS CALENDAR

Feb. 4 Chicago: Meeting, United Airlines Auditorium (Chicago), 8 p.m. Panel discussion on "Air Traffic Control and Flight Safety."

Feb. 5 Baltimore: Dinner Meeting (Dinner 6:30, meeting 8 p.m.), Bendix Radio Division, Towson, Md. "X-15 Research Aircraft Program" by Clayton Clark, North American Aviation, Inc.

Feb. 10 Los Angeles: Specialist Meeting, IAS Building (Los Angeles), 8 p.m. "Boundary Layer Measurements on an Axi-symmetric Body with Spin and Yaw" by Charles H. Thorman.

Feb. 10 Washington: Dinner Meeting (Social period 6, dinner 6:45, meeting 8 p.m.), International Room, Occidental Restaurant. "The Facilities and Capabilities of the Atlantic and Pacific Missile Test Ranges" by Col. Paul T. Cooper, Deputy Commander, Range Air Force Missile Center, and Commander R. F. Freitag, Pacific Missile Test Center.

Feb. 10 Wichita: Dinner Meeting (Social period 6:30, dinner 7, meeting 8 p.m.), Innes Restaurant. "18 Years After Pearl Harbor" by Joe Foss, Governor of South Dakota.

Feb. 11 Niagara Frontier: Technical Meeting, Cornell Aeronautical Laboratory, 8:30 p.m. "Vtol and Stol Research in the U. S." by Robert O. Schade, NASA, Langley Research Center.

Feb. 11 Texas: Specialists Meeting, Arlington State College, 8 p.m. "Some Advanced Concepts in Nuclear Propulsion" by T. G. Flock, Senior Propulsion Engineer, Convair.

Feb. 18 St. Louis: Meeting, McDonnell Aircraft Corp., Auditorium, Building 1, 8 p.m. "Guidance and Control Problems in Astronautics" by Dr. Robert E. Roberson, Chief, Astronautical Sciences, Advanced Engineering Department, Autonetics.

Feb. 19 Columbus: Dinner Meeting (Social hour 6, dinner 7, meeting 8 p.m.), Desert Inn. "The Planned Organization and Program of NASA" by Abraham Hyatt, Assistant Director of Space Flight Development for Propulsion, NASA.

Feb. 19 Los Angeles: Dinner Meeting (Social hour 6, dinner 7, meeting 8 p.m.), IAS Building (Los Angeles). "The Ballistic Missile Program in Perspective" by Col. Charles H. Terhune, Jr.

Feb. 19 New York: Dinner Meeting (Social hour 6, dinner 7, meeting 8 p.m.), Grumman Aircraft Corp., Bethpage, L.I. "Grumman Gulfstream Airplane."

Feb. 24 Detroit: Annual Small Gas Turbine Engine Symposium and Display (Dinner 6:30, technical session 8 p.m.), Large Auditorium, Engineering Soc. of Detroit. "The General Electric T58" by L. J. Nuttall, T58 Applications Engineer, General Electric Co.

# ...and now *Duralar** joins this famous family of fine pencils

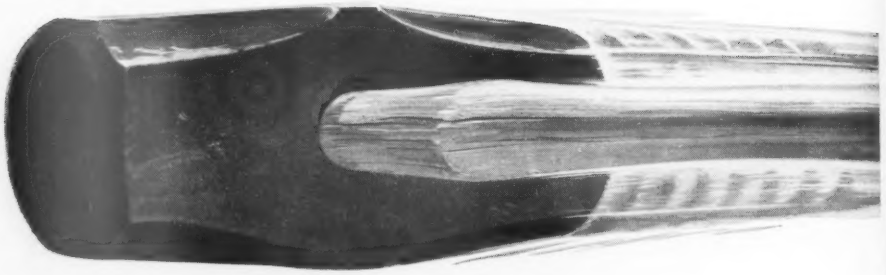
*The only pencil specifically designed for work on matte-surface tracing film of Mylar®, DURALAR is the newest in the complete line of fine MARS drafting products. All are imported from West Germany and made to meet the highest professional standards. Below ● Bright-hued LUMOCHROM pencils in 24 colors for color-coded drafting and perfect reproduction ● LUMOGRAPH graphite drawing pencils in 19 degrees; some degrees available with erasers, some with special chisel points ● TECHNICO lead holders for color and black graphite drawing, with new sure-hold finger grips and degree markings for quick identification; also with clips, for pocket use ● NON-PRINT pencil and leads make notes and sketches that will not reproduce ● Pencil sharpeners in STANDARD and "DRAFTSMAN" models; latter with adjustable point-length feature. ®T.M. FOR duPONT'S POLYESTER FILM

**MARS**

**J. S. STAEDTLER, INC.**

HACKENSACK, NEW JERSEY

# HOW MUCH SHOCK CAN A SYNCHRO TAKE?



Improved Ketay synchros meet or exceed all the requirements of the new Mil Spec 20708, superseding all previous Mil Specs—including the drop hammer shock test, six blows of 2000 ft. lb. intensity, in horizontal and vertical directions.

Offering great accuracy and dependability, these Ketay synchros can perform faithfully under such severe shocks as explosion or recoil . . . in missiles or gun turrets, for example, or in submarines subjected to the impact of depth charges.

Stainless steel housing—far stronger than aluminum—and epoxy resin potting help make Ketay synchros rugged and shock-resistant. These and other design advantages also assure consistent accuracy despite extremes of temperature or moisture. Synchros of one or more sizes smaller and lighter than previously required can often be used because of their superior accuracy.

Ketay is the only source approved by the Navy Bureau of Ordnance currently manufacturing and shipping the new Mil-type synchros. Torque and control units (400 and 60 cps) are available in production quantities in frame sizes from 08 to 23 at no increase in cost.

Ketay personnel are organized to work with engineers designing advanced prototype control systems. Call or write for help in solving your special problems.

*Ketay precision components:*

SYNCHROS
RESOLVERS
POTENTIOMETERS
SERVO MOTORS
TACHOMETERS
SERVO AMPLIFIERS
GYROMECHANISMS

*Catalogues available*

**NORDEN** DIVISION of United Aircraft Corporation

**KETAY DEPARTMENT,** Commack, Long Island, N.Y.

# IAS News

*. . . a record of people and events of interest to Institute Members*

## Fourteenth Flight Propulsion Meeting Planned

***Two-Day Conclave Next Month Will Report on State of the Art in Power for Air and Space Vehicles***

THE INSTITUTE'S 14th Annual Flight Propulsion Meeting (Classified) will feature 13 technical presentations in four sessions, a reception and banquet, and exhibits, in Cleveland, Ohio, on March 5 and 6. An attendance of 700–800 is indicated.

Sessions are scheduled on Air-Breathing Engines, Nuclear Propulsion and Electrical Power Generation, Rocket Propulsion, and Propulsion and Power for Space Flight.

Leaders in planning the event—all on the staff of NASA's Lewis Research Center in Cleveland—are:

*Chairman:* Walter T. Olson, Chief, Propulsion Chemistry Div.

*Cochairman:* Carl F. Schueller, Chief, Propulsion Aerodynamics Div.

*Arrangements Committee Chairman:* Wilson H. Hunter, Staff Assistant, Office of the Director.

*Exhibits Committee Chairman:* Thomas B. Shillito, Head, Section D, Rocket Systems Branch, Propulsion Systems Div.

Others in the IAS Cleveland-Akron Section, whose number precludes their identification here, are assisting in efforts to make this meeting one of the best in its 14-year history. Technical support is being given by the U.S. Air Force.

Clearance forms are being required for this meeting and, together with a full program, were mailed to all IAS members at the end of January with complete instructions.

Special security precautions are being taken with the session on "Nuclear Propulsion and Electrical Power Generation," which will be chairmanned by Col. J. L. Armstrong, USAF, Chief, Aircraft Reactor Branch, Division of Reactor Development, AEC. Three papers will be heard.

Other Sessions, titles of papers, and authors are outlined below.

Walter T. Olson, AFIAS
Program Chairman

### Air-Breathing Engines

"Development of the Aft-Fan Engine," by Neil Burgess, Manager, Commercial Engine Operation, Aircraft Gas Turbine Div., and R. L. Clinton, Manager, X220 Aircraft Programs, Engine Projects Section, Jet Engine Div.; General Electric Co.

"A Turbojet Engine for Mach 3," by B. A. Schmickrath, Assistant Manager of Engineering, Pratt & Whitney Aircraft Div., United Aircraft Corp.

"Prospects and Design Considerations for Hypersonic Flight," by W. H. Avery, B. L. Dugger, and J. H. Walker, Applied Physics Laboratory.

### Rocket Propulsion

"Achievements in Rocket Engine Development for Manned Space Flight," by D. F. Ferris and R. W. Seaman, Reaction Motors Div., Thiokol Chemical Corp.

"The Prepackaged Concept of Liquid Rocket Engines," by Ralph J. Kaufmann, Liquid Rocket Engine Branch, Power Plant Div., Bureau of Aeronautics.

"Application of High Thrust Storable Liquid Rockets," by R. C. Stiff and John C. Moise, Aerojet-General Corp.

"Development of a Propulsion System for Minuteman," by Bryce Wilhite, Technical Director and Assistant Manager, Utah Div., Thiokol Chemical Corp.

### Propulsion and Power for Space Flight

"Development Aspects of a Million-Pound Thrust Liquid Rocket Engine," by S. K. Hoffman, Vice-President and General Manager, Rocketdyne Div., North American Aviation, Inc.

"Comparison of High-Energy Propellants in Final Stages," by H. M. Henneberry, M. L. Moseson, and S. C. Himmel, Lewis Research Center, NASA.

"Propulsion Requirements for Mars Flight" (tentative title), by Krafft A. Ehricke, Assistant to the Technical Director, Astronautics Section, Convair, Div. of General Dynamics Corp.

STEPS IN THE RACE TO OUTER SPACE

# *Mars Snooper*

This nuclear-fueled reconnaissance craft is preparing to land on Mars' outermost satellite, Deimos—12,500 miles away from the "red planet" (center) and 35 million miles away from the Earth. Deimos' gravitational pull is so slight that a featherlight landing could be made, and a take-off could be accomplished with little more than a shove of the pilot's foot! (At Deimos' orbital speed, such a push would start the ship back to Earth at 3000 miles per hour.)

Our spaceship is designed to fly in two directions—nose first as a space rocket and tail-first as a ramjet airplane. Propulsion for both is provided by a single atomic heat source, reacting with hydrogen for rocket thrust, and with atmosphere to power the ramjets.

Travel to Mars, braking for landing, take-off and re-entry are accomplished by rocket-thrust. As the ship approaches the Earth's atmosphere, it assumes a tail-first attitude. The "petal doors" enclose the rocket nozzle, and the ship is transformed into a high speed, ramjet airplane with M-shaped wings. Control fins are located in the nose of the craft, near the crew's quarters.

**ENGINEERS • SCIENTISTS**

***ARMA*** needs key men to augment a broad research program in missile guidance and space technology. As designer and developer of all-inertial navigation systems for TITAN and ATLAS ICBM's, ***ARMA*** provides a stimulating atmosphere where creative talents can develop. Write to E. C. Lester, Professional Placement, AE-2, ***ARMA*** Division, Garden City, N.Y. A Division of American Bosch Arma Corporation.

***AMERICAN BOSCH ARMA CORPORATION***

# Dynamics-Aeroelasticity Specialists Meeting

*Texas Conference Draws Attendance of 228; Proceedings Available*

SEVENTEEN papers were presented during the 2-day IAS National Specialists Meeting on Dynamics and Aeroelasticity at Fort Worth, Tex., Nov. 6 and 7. The meeting was attended by 228 persons.

A panel session on "Flutter and Aeroelasticity in the Space Age" highlighted the meeting on the evening of the 6th. The panel discussion was moderated by Martin Goland, Vice-President, Southwest Research Institute. Panel members were: Holt Ashley, MIT; Millard V. Barton, Thompson Ramo Wooldridge Inc.; R. L. Bisplinghoff, MIT; I. E. Garrick, NASA Langley Research Center; Samuel Levy, General Electric Co.; Walter J. Mykytow, Aircraft Laboratory, WADC; Phillip W. Zettler-Seidel, Army Ballistic Missile Agency, Redstone Arsenal.

The *Proceedings*, containing unclassified papers, may be obtained from the Special Publications Department, IAS, 2 East 64th St., New York 21, N. Y. The IAS member price is $3.50; price for nonmembers is $6.00.

This National Specialists Meeting—conceived and run by members of the Texas Section—was one of the outstanding IAS meetings of the year. The Editors are indebted to Vernon A. Lee, Section Secretary, for the photographs.

**SIGN IN—IF YOU PLEASE**

As usual, the registration desk—
shown here in the Silver Lounge of the Hotel Texas in Fort Worth—
was the scene for renewing acquaintances and accounting for oneself.
The group is unidentified, but we recognize
IAS Western Region Manager E. W. Robischon,
standing second from the right (*photo, top left*).

**SOMETIMES ATTENTION IS RAPT. . .**

. . .as is the case in this photo (*center left*)
taken during the presentation of a paper
at one of four sessions comprising the 2-day meeting.

**A RESPITE BETWEEN SESSIONS. . .**

. . .brings together (*left to right in photo at left*)
R. L. Bisplinghoff, Professor of Aeronautical Engineering, MIT,
who was Chairman of Session III;
Phillip W. Zettler-Seidel, Scientific Assistant to the
Director of Aeroballistics Laboratory,
Army Ballistic Missile Agency, Redstone Arsenal,
who was a panelist;
and P. T. Mahaffey, Structures Group Engineer,
Structures Dynamics Group, Convair, Fort Worth,
who presented a paper in Session III.

**PANELISTS ALL**

(*Right*) Members of the Panel Discussion on "Flutter and Aeroelasticity in the Space Age" are (*left to right*): I. E. Garrick, Chief, Dynamics Loads Div., Langley Research Center, NASA; Samuel Levy, Manager, Stress Analysis Engineering, Missile and Ordnance Systems Dept., General Electric Co.; Millard V. Barton, Manager, Engineering Mechanics Dept., Guided Missile Research and Development Div., Thompson Ramo Wooldridge Inc.; Walter J. Mykytow, Assistant Chief of Dynamics Branch, Aircraft Lab., WADC; Martin Goland (Moderator), Vice-President, Southwest Research Institute; R. L. Bisplinghoff; Phillip W. Zettler-Seidel; and Holt Ashley, Dept. of Aeronautical Engineering, MIT.

CECO NEWS

CHANDLER-EVANS SYSTEMS • CONTROLS WEST HARTFORD, CONNECTICUT

# Chandler-Evans Announces New High-Temperature Test Center

**LATEST CECO DEVELOPMENT TOOL:** Two structures make up the Chandler-Evans Thermo-Research Center. One (shown above in foreground) is a concrete and steel, insulated and soundproofed Control House.

The second structure (background above) is an "open air" Test Platform, sheltered from the elements by a sheet metal roof containing plastic blow-out sections. Test Chambers and all associated equipment are installed on this platform.

## CECO Facility Tests Fuel Devices In Environments To 1000°F.

West Hartford, Conn. (CECO)—Completion of a new and vastly capable Thermo-Research Center has been announced by Sidney A. Stewart, General Manager of Chandler-Evans. The 100% company-owned facility is considered to be unique in the modern aircraft industry. It is designed to subject sensitive fuel mechanisms and other hydraulic devices to elevated temperatures similar to those developed in ultra high-speed flight.

As a development tool, the Center is expected to provide answers to many questions that have perplexed engineers since advanced air speeds first began to create critical high-temperature problems.

Chandler-Evans has been "hot-testing" aircraft engine accessory products for a number of years. Initially, relatively simple facilities were equal to the task. But, as aircraft and missile speeds advanced into Mach ranges, it became apparent that temperatures problems [illegible] (to accommodate 300-hour fuel system tests, for example) can be carried out twenty-four hours a day, seven days a week.

### Others to Use Lab

**CECO's new Thermo-Research Center has been made available to others, according to Ercole J. Vitali, Manager of the Company's Engineering Test and Experimental Departments.**

**On a limited basis, the laboratory and its staff will be put at the disposal of manufacturers who are similarly concerned with the functional performance of liquid fuels, fuel system components, and other hydraulic equipment when subjected to the stresses of elevated temperature. Ambient and fuel temperature capabilities currently specified are 1000°F. and 500°F. respectively.**

**Vitali went on to say that subcontract customers can gain valuable time and save money as well by calling on CECO's [illegible]**

## New Center Has Unique Features

The Control Console in CECO's newest test facility incorporates latest state-of-the-art instrumentation and provides for push-button ease of operation. Any malfunction in any part of the system activates both audible and visual alarms. Electrical interlocks automatically shut down the system and indicate the specific area of malfunction.

If the operator does not or cannot take the necessary corrective steps within a predetermined amount of time, required corrections are made automatically and the test is resumed.

### Engineered for Safety

While the Test Platform with its Ambient Chambers can easily be seen through a maximum safety window in the forward wall of the Control House, all tests are 100% remotely controlled. Operators set and control temperatures and pressures, and assemble all necessary data at the Control and Instrumentation Console.

The entire CECO Thermo-Research Center has been painstakingly engineered to provide optimum safety, both for operating personnel and for the valuable mechanisms being tested.

So thorough are the safety precautions that despite the hazards inherent in handling fuels at elevated temperature, lowest premium cost fire insurance premiums on this facility are in the category ("Sprinkler Rating").

### Described as "Operator-Proof"

A highly complex operator-overriding system, developed especially for this facility, assures proper operation at all times. Operator errors, if and when they occur, are corrected automatically.

### Fuel Density Indicator

A meter in the Control House gives continuous indication of fuel density. It gets its signal from the intensity of radiation through a section of the fuel conduit. Isotope Cesium 137 is used in this radiation process.

## S. A. Stewart Lauds CECO's New Test Lab

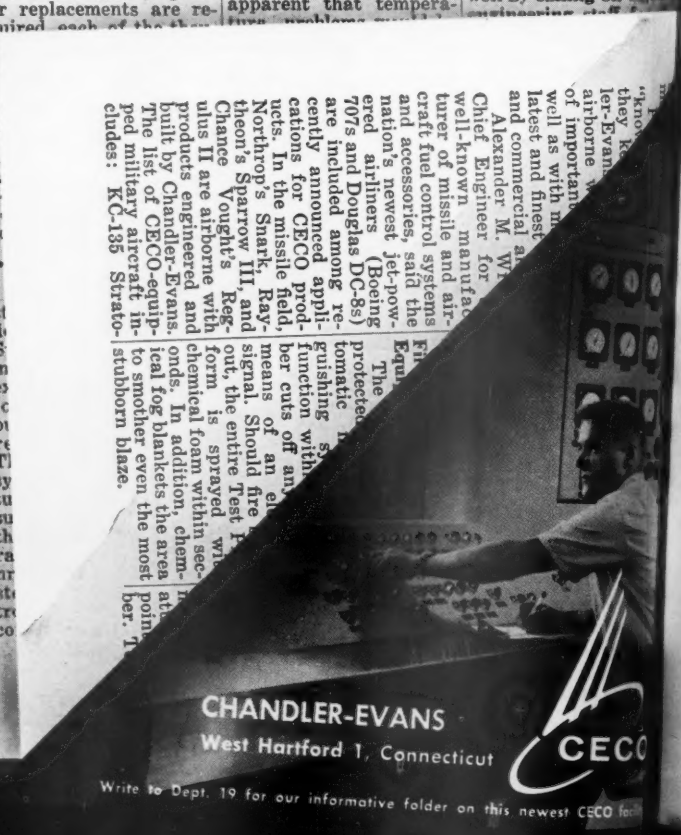
"This unique engineering tool will enable CECO to continue developing superior products empirically," said Sidney A. Stewart, General Manager of Chandler-Evans, when the company's new Thermo-Research Center was unveiled for the aircraft industry.

He went on to point out that high-temperature problems have become increasingly critical with advancing speeds of air and space vehicles. "We expect to find in this new laboratory definitive answers to a variety of questions relative to the precise metering of liquid fuels at high temperatures," he said.

Further underscoring the importance of *temperature extremes* in the modern aircraft and missile industry, Stewart mentioned concurrent activities in the cryogenics field. He said CECO is designing and producing devices for use in liquid nitrogen systems, for example, where temperatures of —330° F. are encountered.

### Part Numbering

To simplify trouble-shooting and minimize time losses when repairs or replacements are required, each of the three [illegible]



## *Technical Film Catalog*, in Fifth Year, Contains 4,200 Listings; Still Growing

The ARDC-sponsored *Technical Film Catalog* has over 4,200 listings of motion picture films covering the various stages, from concept through flight, of the research and development of aircraft, helicopters, missiles, systems, rockets, space vehicles, etc., as well as support operations and equipment, materials, and fabrication methods—altogether 3,900 subjects falling within fields of interest to the Air Force. It is an active, authentic, and up-to-date source of technical information as recorded on motion picture film.

The *Catalog*, which is in its fifth year, is being compiled by the Institute of the Aeronautical Sciences, under contract to the ARDC, with its operating office at the IAS facility at 3380 N. Harbor Drive, San Diego, Calif.

This rapidly growing *Catalog* lists both classified and unclassified films and is designed to enable the USAF, the aircraft industry, or any other qualified organization to locate quickly motion pictures of valuable data needed for the advancement of research, instruction, or other technical requirements relating to the Air Force mission. The method used in cataloguing this film information reduces to a minimum the necessity for consulting or handling the actual film in order to determine its suitability to the specific need. Also, if used to its fullest potential, this recorded information will prevent the costly duplication of research films already available.

The *Technical Film Catalog* acts only as an information center and does not maintain a film library, nor does it enter into negotiations for obtaining the films. It is not prepared for distribution in its entirety, other than the five sets specified in the contract which are maintained at the following locations:

Headquarters, Air Research & Development Command, RDSBT, Andrews AFB, Washington 25, D.C.

1350th Motion Picture Squadron, Motion Picture Film Depository, Air Photographic & Charting Service (MATS), Wright-Patterson AFB, Ohio.

1356th Film Library Flight, Air Photographic & Charting Service (MATS), 8900 So. Broadway, St. Louis 23, Mo.

Institute of the Aeronautical Sciences, 2 East 64th St., New York 21, N.Y.

Technical Film Catalog Office, IAS Building, 3380 N. Harbor Drive, San Diego 1, Calif.

However, the San Diego Catalog office does conduct specific subject searches and compiles bibliographies on unclassified films upon request. Classified information will be furnished only in accordance with applicable security regulations.

Government agencies and entities under Government contract (in connection with such contract) in need of filmed technical data are urged to take advantage of this service by contacting the San Diego office or one of the facilities listed above.

## United Aircraft Forms Subsidiary for Research

United Aircraft Corp. has formed a new company, United Research Corp., a subsidiary, to sponsor and support basic research. Officers of the new corporation are Lt. Gen. Donald L. Putt, USAF (Ret.) (F), President; Wright A. Parkin, Vice-President; Donald H. Culver, Treasurer; Charles H. Chatfield, Secretary. Chairman of the Board will be William P. Gwinn, President of United Aircraft Corp.

General Putt, who was Deputy Chief of Staff, Development, Headquarters, USAF, before his recent retirement, will be advised by a scientific directorate consisting of Dr. Isidor I. Rabi, of Columbia University and winner of 1944 Nobel Prize for Physics; Dr. C. Richard Soderberg (F), Dean of Engineering, M.I.T.; Dr. H. Guyford Stever (F), Assistant Dean of Engineering, M.I.T.; Dr. Bernard Lewis, Combustion & Explosives Research, Inc., Pittsburgh; and S. Allan Kline, President, Sierra Metals Corp.

Lt. Gen. Donald L. Putt, USAF (Ret.)

Besides his duties as President of United Research, General Putt will serve United Aircraft as its Assistant Director of Research.

The first assignment for the new corporation is to support research in advanced propellants for missile and spacecraft in cooperation with Stanford Research Institute. Similar agreements with other appropriate research institutions are being planned for future research.

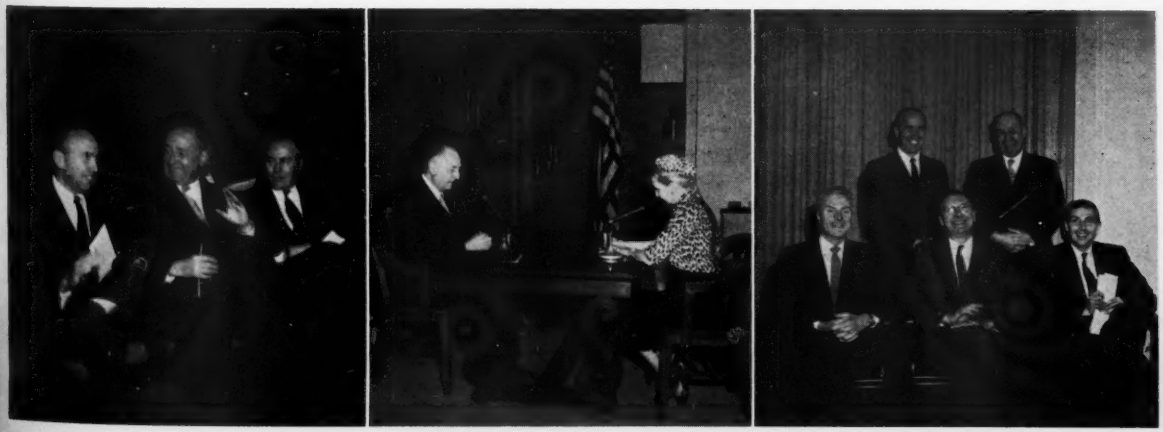
## Special Service Offered Through Pacific Library

A special service for aero/space engineers and scientists is offered on the West Coast by the Pacific Aeronautical Library through its *Uniterm Index* of periodical literature in the field.

As periodicals are received, articles of interest are indexed according to a "unit term" and corresponding number. This index is available every 7 days. In addition, a posting list with these "uniterms" or headings in alphabetical and numerical order is issued every 3 weeks. Three

(*Continued on page 60*)

**The Twenty-Second Wright Brothers Lecture was delivered in Washington, Dec. 17, by Maurice Roy before an audience of 300 people. Here, M. Roy is shown before the lecture (*left*) with IAS President Edward C. Wells and Director S. Paul Johnston; (*center*) giving an interview for Voice of America; and (*right*) standing with Mr. Wells behind the lecture discussers Johnny Green, Hugh L. Dryden, and Al Flax. M. Roy repeated the lecture before IAS audiences in Cleveland, Dallas, and Los Angeles on Dec. 18, 19, and 22, respectively.**



# Now, Fluoroflex®-T hose of Teflon® for 4000 psi service

**The only assemblies** that could pass the rigid test established for a 4000 psi hydraulic system, Fluoroflex-T ¼" lines again *proved* their reliability for high pressure service.

**In punishing impulse tests** by both the aircraft manufacturer and Resistoflex, the ¼" assemblies were subjected to 550,000 impulse cycles, then proof pressure tested at a sustained 10,000 psi. There were *no* failures at all.

**The severest service** always singles out the hose with the highest performance capabilities. If you're now planning a 4000 psi system, write for test data. Dept. 186, RESISTOFLEX CORPORATION, Roseland, New Jersey.

*® Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.*
*® Teflon is DuPont's trademark for TFE fluorocarbon resins.*

*Originators of high temperature fluorocarbon hose assemblies.*

Resistoflex

ROSELAND, NEW JERSEY • WESTERN PLANT: BURBANK, CALIF. • SOUTHWESTERN PLANT: DALLAS, TEX.

# DATELINE world

PROFESSIONAL NOTES AND REPORTS

*Engineering and Scientific Briefs from Correspondents Around the Globe*

### Scientific Progress in Soviet Latvia Noted

◆ The following account of Latvian scientific progress since the country's incorporation into the Soviet domain appeared some time ago in the *Moscow News*, under the by-line of a Latvian correspondent:

"Scientific research in our Republic is coordinated by the Academy of Sciences of the Latvian Republic, founded in 1946. There was no Academy of Sciences in bourgeois Latvia and whatever research work there was, was conducted at the University.

"Today, our Academy of Sciences has 14 research institutes, an independent astronomy department, the Rainis Literary Museum, and a big scientific library.

"The Institute of Power Engineering and Electrotechnics (Director, Academician P. Plaude) studies power engineering throughout the Republic and has been responsible for designing many new types of electrical machinery, including machines for the railways which are being introduced in use. The staff of the institute cooperates with the Riga Electrical Machine-Building Plant.

"Other institutes also work in close cooperation with industry. For instance, the Institute of Machine-Building (Director S. Ainbinder) is helping Latvian plants and industrial enterprises in other Republics to apply its theoretical conclusions on the durability of materials, the resistance of machinery to wear, and the control and automation of industrial processes. Instruments and appliances for measuring galvanized plating, for conductor welding, etc., devised on the basis of research at the institute, are now in wide use.

"Another body which works closely with industry is the Institute of Physics (Director I. Kirho), which conducts theoretical and technical research in the peaceful uses of atomic energy. A variety of instruments has been designed, based on the use of radioactive isotopes, which help in the automation of industrial operations. Some of these instruments have been shown at international exhibitions.

"In the light of the big new tasks involved in the development of the chemical industry, the creation of new synthetic materials, plastics and artificial fibers, the chemists of the Academy of Sciences of Latvia and of the Department of Chemistry of the Riga Polytechnical Institute are stepping up their research in these spheres. Particular attention is being devoted to work on artificial and natural high-molecular compounds and polymers."

### 12-Month Report on IGY Given by U.S.S.R. Institute

◆ On July 1, 1958, the Arctic Institute of the U.S.S.R., through the Soviet Home Service in Moscow, issued the following preliminary report on the Institute's work during the first 12 months of the International Geophysical Year:

"More than 20 aerological points are operating over the enormous distance in the Arctic, from Franz Joseph Land to Cape Prince of Wales. They have launched 18,000 radiosondes which have enabled valuable information to be obtained on the distribution of temperatures and air pressure up to 30,000 meters, on humidity, and on the direction and speed of winds. Of particular interest is information on the drift of heat to the Arctic from more southerly latitudes.

"During the present IGY, apart from the artificial earth satellites, the new technology of jet propulsion has been used for the first time to enable the altitude of the radiosondes to be increased considerably and to obtain completely new information on the density, pressure, and temperature of the air.

"On shore observation points and on drifting stations and islands, Soviet scientists have made more than 30,000 actinometric observations of solar radiation. A great volume of new information has been sent by the institute to the central collection office of the IGY program."

The radiosonde, developed about 2.5 years ago, is a light, expendable radio transmitter used extensively for meteorological soundings at various levels of the atmosphere. Combined U.S. military and Weather Bureau launchings reach almost a quarter of a million yearly. The jet propulsion mentioned in the Soviet item is believed to be similar to the rocket-balloon vehicle utilized in the United States.

Promising further revelations when discoveries can be fully interpreted, the Soviets have already made important IGY contributions in the field of solar radiation. It is believed that eventually the Soviet studies will enable scientists to forecast the time of solar flares, making it possible to launch special instruments beforehand to record the phenomena.

### New Fiber Credited With Unusual Stability

◆ Among late-1958 reports on polymer work in the U.S.S.R. is the announcement that Prof. Z. Rogobin and scientific coworkers Z. Zazulina and M. Martsinkovskaya, from the Chair of Artificial Fibers of the Moscow Textile Institute, have developed a fiber from fluorine-containing polymers, which they call "Ftorlon." It is described as stronger than most synthetic and natural fibers, and very stable in the presence of active chemicals. It is claimed that the new material is unaffected by extensive exposure to solar rays and does not lose its properties after being submerged 60 days in concentrated nitric acid.

Also, in the Ryazan Machine Tool Construction Factory, a new protective device made of this material was designed recently for the "163" universal screw-cutting machine. It is expected that the device will save more than 150,000 rubles per year. Engineers at the factory are said to be attempting machine construction from polyamides, a new type of very strong plastic.

### Thermonuclear Reaction Is Studied in U.S.S.R.

◆ From the Soviet press comes word that several methods of obtaining hot plasma are presently under study at the Institute of Atomic Energy, Academy of Sciences, U.S.S.R.

One of these methods consists of heating produced by the pressure which is the result of a changing magnetic field.

Other methods now investigated include "injecting" plasma with ions which previously are accelerated to needed energy, and application of powerful short-term electrical discharges.



XUM

EDITORIAL

# APPROPRIATE AWARD

In the October 1958 issue of this magazine, we announced the establishment of a Space Transportation Award by The Hill Family Foundation of St. Paul, Minn. At the same time, the several provisions under which the award would be made were outlined, and a Board of Award designated.

At the time of the announcement it was anticipated that no selection would be made for the year 1958. In fact, the resolution adopted by the Directors of The Hill Foundation specified that the first award should be made at the IAS Honors Night Dinner in January, 1960. Subsequently, however, during the course of arranging for the first meeting of the Board of Award, the Hill Foundation officials indicated that they would have no objection to making an award for 1958, provided that the Board of Award so desired and that a suitable awardee could be selected.

The first meeting of the Award Board was held in Washington on Monday, December 15. Dr. H. Guyford Stever, Associate Dean of Engineering of M.I.T. and former chairman of the NACA Space Technology Committee, was elected chairman. Recognizing the potential of the new award in the rapidly developing field of aero/space technology, the Board gave full consideration to the objectives of The Hill Foundation in establishing its procedures and specifications and in considering possible candidates.

Very early in the discussion it became apparent that one individual stood out as the proper candidate—Dr. Robert H. Goddard. There was one difficulty, however; no provision had been made under the grant for making a posthumous award. The Hill Foundation representative was asked for a ruling. It was clear, in his opinion, that the intent of The Foundation was to honor living Americans for outstanding work in the field of space transportation, but, in view of the extraordinary contribution made by the proposed candidate, there could be no possible objection to making the initial Hill Award to him.

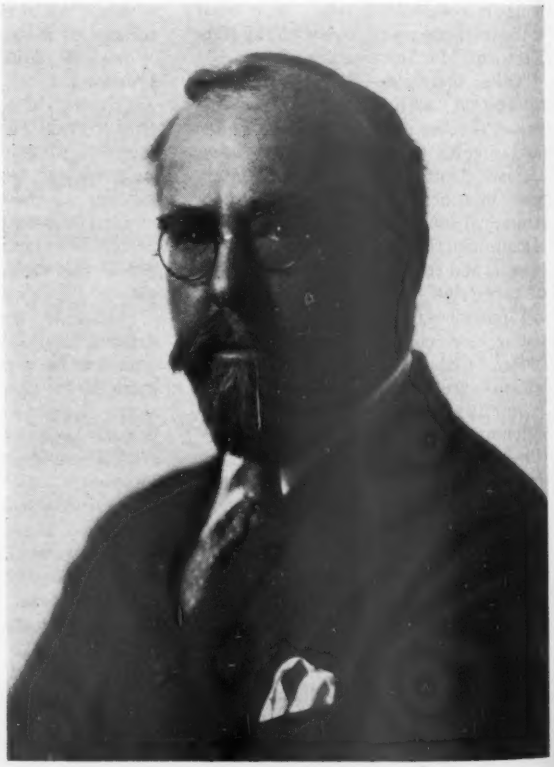
It was the consensus that Dr. Goddard, in the face of ridicule and opposition, had the vision and the courage to initiate the research that has led to man's conquest of Space.

Therefore, by unanimous action of the Board, the 1958 Hill Space Transportation Award was voted to Dr. Robert H. Goddard, Father of American Rocketry, for "significant contributions indicative of American enterprise and ingenuity in the art and science of space flight." The certificate and the $5,000 honorarium were presented to his widow (and lifelong assistant), Mrs. Esther Goddard, at the Honors Night Dinner in January. Cortlandt Hill, son of Louis W. Hill, made the presentation.

We think that the Board has made a most appropriate selection. In thus honoring Dr. Goddard, the Award has been established at the highest possible level. Subsequent winners, whoever they may be, will take their places in the galaxy of the Great Pioneers, as do those who win the great aeronautical awards—the Collier and the Wright Trophies. S.P.J.

## BOARD OF AWARD

- Dr. Hugh L. Dryden, Deputy Administrator, NASA
- Dr. W. Randolph Lovelace, II, Director, Lovelace Foundation
- Dr. Clark B. Millikan, Director, GALCIT
- Dr. Athelstan F. Spilhaus, Dean, Institute of Technology, University of Minnesota
- Dr. H. Guyford Stever, Associate Dean of Engineering, M.I.T.
- Dr. Fred L. Whipple, Director, Smithsonian Astrophysical Observatory, Harvard University
- Dr. T. P. Wright, Vice-President—Research, Cornell University



Louis W. Hill



XUM

**The First**
**Louis W. Hill**
**SPACE**
**TRANSPORTATION**
**AWARD**

FOR . . . *"significant contributions indicative of American enterprise and ingenuity in the art and science of space flight"* is made

## to . . . ROBERT HUTCHINGS GODDARD

(1882-1945)

Dr. Goddard devoted his life from the turn of the century until the time of his death in 1945 to all phases of work on rockets. His vision, starting with speculation and theoretical development, embraced the scientific concepts that are known as basic today, combined with practical experimentation and development years ahead of his time even to the choice of fuels and carried out often in the face of opposition from other reputable scientists. He foresaw for his rockets the use we now make of them for geophysical and astrophysical research – the understanding of space. His developments laid the groundwork for present space vehicles.

It is most appropriate that Mrs. Goddard, who actively participated and assisted him in much of this pioneering work, should receive the award honoring her husband's remarkable contributions.

**RESOLUTION by the Board of Award**

Whereas it is the intention of the Board of Award of the

LOUIS W. HILL SPACE TRANSPORTATION AWARD

in conformity with the intention of the Hill Family Foundation to recognize in future awards the contributions of contemporary American scientists for the purpose of "encouraging and supporting fundamental research and the early application of new knowledge in behalf of the welfare of mankind," the Board felt it would be remiss in the first award if it did not acknowledge our debt to Robert H. Goddard for his pioneering activities, vision, and fortitude which laid the foundations for the development of modern space vehicles.

HUGH L. DRYDEN
W. RANDOLPH LOVELACE, II
CLARK B. MILLIKAN
ATHELSTAN F. SPILHAUS
H. GUYFORD STEVER
FRED L. WHIPPLE
T. P. WRIGHT

*Over 8 years ago, Mrs. Esther Goddard selected the IAS as the proper repository for many of the experimental items that remained from Dr. Goddard's early work with liquid fuel rockets. Much of this material has since been sent to the Goddard Museum at Roswell, New Mexico, but in the Fall of 1950 (and for several years thereafter), it was a part of our historical exhibit and was described in the Institute's historical publication* AERONAUTICA. *As a part of this announcement of the first Hill Space Transportation Award, it seems fitting to reprint in the following pages the material that appeared in* AERONAUTICA *almost 10 years ago.*

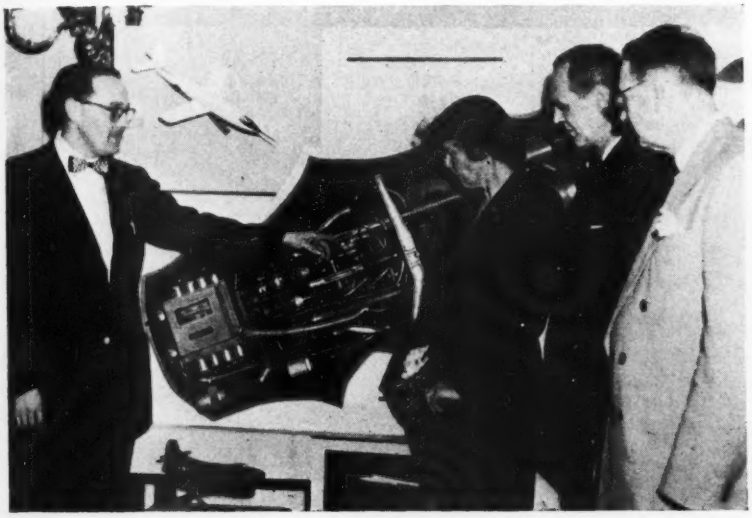
XUM

Aeronautica

Published by the

Institute of the Aeronautical Sciences, Inc.

Vol. 2 OCTOBER-DECEMBER, 1950 No. 4



*Left to Right:* Lovell Lawrence, Jr., President, Reaction Motors, Inc.; Mrs. Robert H. Goddard; Dr. Howard B. Jefferson, President, Clark University; Francis W. Roys, Dean of Engineering, Worcester Polytechnic Institute.

# Goddard Memorial Exhibit Opens

## *Mrs. Esther Goddard Is Honored at Reception and Luncheon.*

DECEMBER 1, 1950, MARKED the opening of the Goddard Memorial Exhibit at the Institute museum. Mrs. Esther Goddard came down from Worcester to open officially the exhibit, which contains equipment and apparatus used by the late Dr. Robert H. Goddard in his pioneering work on rockets. Through the kindness of Mrs. Goddard, this collection was given to the Institute and will remain as a permanent part of the I.A.S. Archives.

A reception was held for many friends of Mrs. Goddard, members of the American Rocket Society, and those interested in her husband's work. Also present were members of the I.A.S. Council and Staff. This was followed by a buffet luncheon, and the exhibit was opened to the public later in the afternoon. Among those present were Harry F. Guggenheim, without whose aid, through the Guggenheim Foundation, much of Dr. Goddard's work could not have been carried on; Lawrence Rockefeller; Dr. Charles G. Abbot, Secretary Emeritus, of the Smithsonian Institution, which sponsored much of Goddard's early work; Dr. and Mrs. Howard B. Jefferson, President of Clark University where Dr. Goddard started his early work; Dr. and Mrs. C. N. Hickman (Dr. Hickman did much of the early powder rocket work); and the men who worked with Dr. Goddard and are carrying on their work in rockets with the Rocket Department at the Curtiss-Wright Corporation. We also had with us representatives of the Navy, of Reaction Motors, and of the Aerojet Engineering Company.

The exhibit is divided into four sections that correspond to similar periods in the life of the inventor. The first panel covers his work in solid fuel pro-

(*Continued on page 8*)

## Re Aeronautica

This issue is devoted largely to Dr. Robert H. Goddard—his life and his work. We are fortunate indeed to have the material available for exhibit so that more may know of his achievements and contributions. We urge all Historical Associate members and their friends to visit the new exhibit and feel sure that they will be amply rewarded.

We are pleased to report that interest in the Archives is growing, and that many I.A.S. members are joining the ranks as H.A. members. Our mailing list now numbers over 525. After receiving their first copy of AERONAUTICA, perhaps some of the new members have suggestions, questions, or comments. Please mail these directly to AERONAUTICA, 2 E. 64th St., New York 21, N.Y.

*Copyright 1951 by the Institute of the Aeronautical Sciences, Inc.*

(Reprinted from Aeronautica, December, 1950)

# The Robert H. Goddard M

*(Top)* A portion of the collection, devoted to experiments carried on at Auburn between 1918 and 1929.

*(Below)* General view showing approximately half of the exhibit. Full-size rocket in the foreground is type used in experiments of 1936–1938.

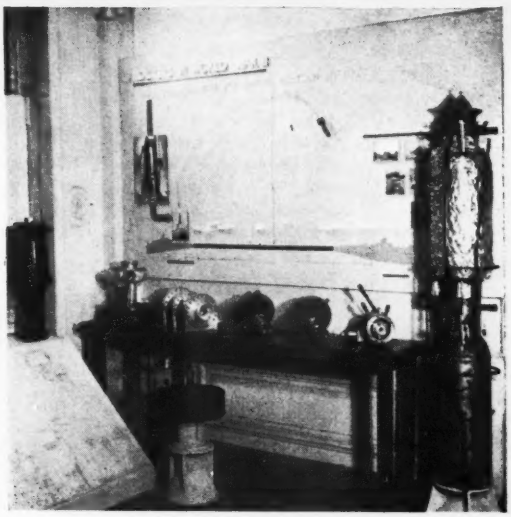
The Robert H. Goddard Memorial Exhibit, made possible through the donation by Mrs. Esther C. Goddard of the library and apparatus used by her late husband, has now been established as a permanent part of the Aeronautical Archives of the Institute.

To mark the opening of the exhibit on December 1, 1950, a buffet luncheon and reception was held at the Institute building, at which time Mrs. Goddard officially turned over the

# Memorial Exhibit

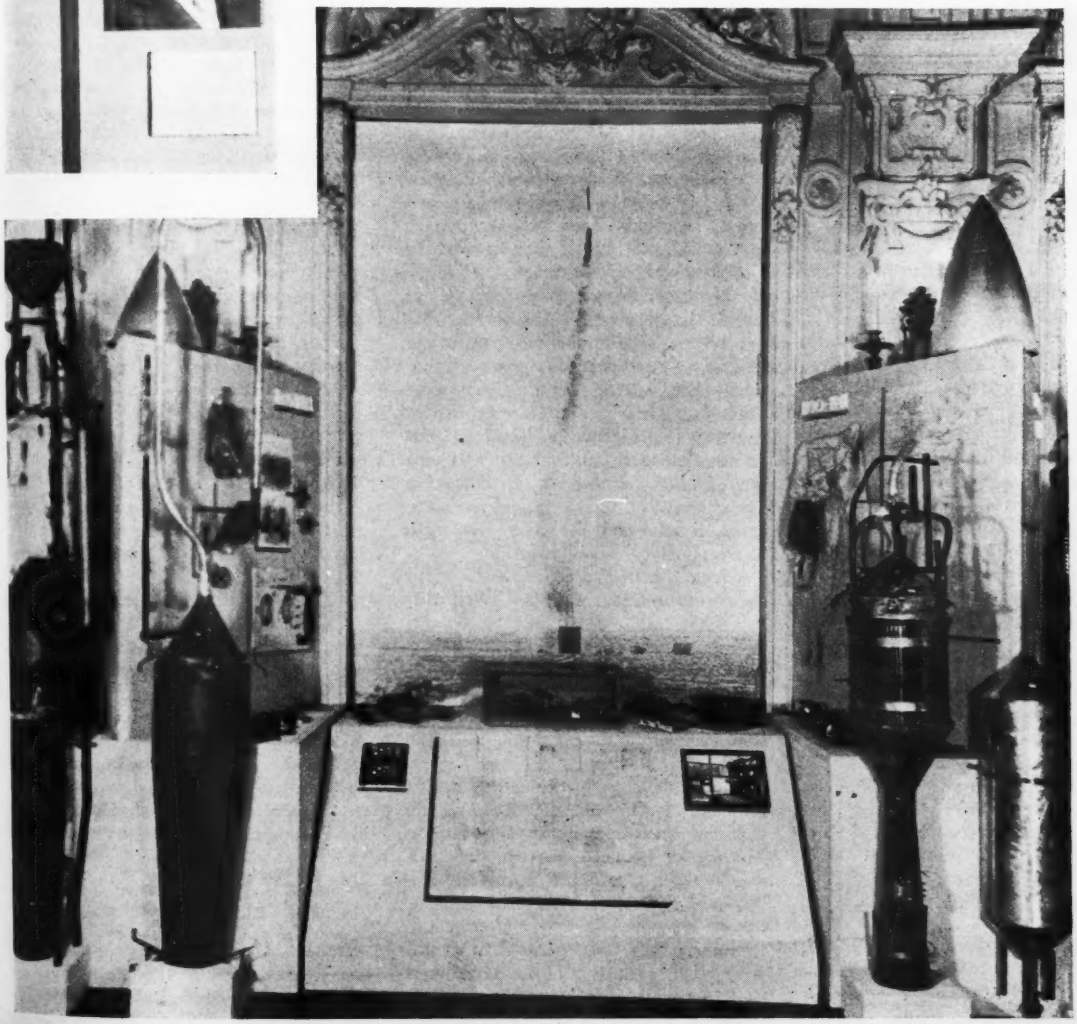
exhibit to the I.A.S. The reception was attended by friends and admirers of Dr. and Mrs. Goddard, some of whom had worked with Dr. Goddard. A number of members of the American Rocket Society and members of the I.A.S. staff were also present.

The Robert H. Goddard Memorial Exhibit, as well as the rest of the Aeronautical Museum, is open to the public from 10:00 to 4:00 on weekdays.



***(Top)*** **This panel illustrates the fact that the German V-2's incorporated many of Dr. Goddard's ideas and inventions.**

***(Below)*** **Centered around a picture of the successful L-14 launching, in 1937, are displayed items connected with Goddard's work at Roswell, N.M., 1930–1941.**



(Reprinted from Aeronautics, December, 1950)

DR. ROBERT H. GODDARD "was born in Worcester, Mass., October 5, 1882. His early schooling was obtained in Boston, where he lived until he was sixteen. His college work was taken at Worcester; he was graduated from Worcester Polytechnic Institute in 1908 and became an instructor in physics there while pursuing graduate studies at Clark University. He received his M.A. degree from Clark in 1910 and his Ph.D. in 1911. He later joined the Clark faculty, where he rose from instructor to assistant professor and, finally, to full professor. He continued to be connected with Clark until 1943, part of the time on leaves of absence.

"As a young professor of physics, Dr. Goddard made important studies on the conduction of electricity in powders, the development of crystal rectifiers, the balancing of airplanes, and the production of gases by electrical discharges in vacuum tubes.

"In the 1912–1913 season he served as research fellow at Princeton University. During this period he produced the first laboratory demonstration of mechanical force from a 'displacement current' in a magnetic field.

"These investigations, however, were only more or less incidental to the real interest and accomplishment of his life. As early as 1899, when he was only seventeen, he began to speculate about conditions in the upper atmosphere and beyond and to evaluate various proposed methods of reaching these regions physically, for exploration. A notebook of his, dating back to October 19, 1899, contains such speculations and mentions the possibility of employing rockets for this work.

"In 1907 he prepared and submitted for publication a manuscript suggesting that heat from radioactive materials could be used to expel substances at high velocity from an orifice, thus furnishing jet propulsion sufficient to navigate an interplanetary space. The manuscript, still in existence, is an interesting document. It was ahead of its time, however, and was forthrightly refused when Dr. Goddard submitted it seriatim to the *Scientific American*, *Popular Science Monthly*, and *Popular Astronomy*.

"The idea of using hydrogen and oxygen as fuels for an interplanetary rocket and the construction of such a rocket according to the multiple or step-rocket principle occurred to him in 1909. After considerable calculation he put the theory into satisfactory form in the winter of 1912–1913. His computations included the possible use of smokeless powder for the propellant, as well as hydrogen and oxygen.

"His actual experimental work began about 1914, upon his return to Clark University as an instructor and honorary fellow in physics. The first tests were made with various types of ship rockets and were continued with larger solid-fuel rockets that he constructed.

"By 1916 he had nearly reached the limit of what he could do with his own resources. In that year he began to seek support for his work, his principal instrument of solicitation being a lengthy technical paper he had prepared on rocket possibilities which he submitted to several foundations and other prospective donors.

"It was as a result of sending this paper to Dr. Charles D. Walcott, then secretary of the Smithsonian Institution, that he obtained his first grant of funds from that source. Most of his paper was later incorporated in the report entitled 'A Method of Reaching Extreme Altitudes,' published in 1919 as a part of the *Smithsonian Miscellaneous Collections*, Vol. 71, No. 2. It has since been republished by the American Rocket Society in book form.

"Total grants from the Smithsonian amounted to about $11,000. With this small sum Dr. Goddard laid the foundation for virtually all of his later achievements and initiated the world-wide interest in rockets and jet propulsion which has become of major importance not only to scientists and engineers but to all men and nations.

"After the entry of the United States into World War I in 1917, Dr. Goddard was assigned to explore the military possibilities of rockets. He succeeded in developing a number of promising military rocket devices. One of these was a rocket for long-range bombardment, the motor of which operated intermittently during flight, solid-fuel propellant charges being injected rapidly into the combustion chamber by a method similar to that used in loading repeating rifles.

"He also developed several types of relatively short-range rocket projectiles intended to be fired by infantrymen at tanks or other military objectives, the firing mechanism being a simple launching tube held in the hands and steadied by two short legs. Some of these devices were in many respects similar to the 'Bazooka' of World War II and were, of course, that weapon's progenitors.†

"A number of these new weapons were demonstrated at the Aberdeen Proving Ground on November 10, 1918, before representatives of the Signal Corps, the Air Corps, the Army Ordnance, and others. The demonstrations went off quite successfully, and the Air Corps representatives particularly expressed interest in continuance of the work, with experimental trials of Goddard rockets in actual combat. The Armistice next day put an end to the war, however, and also ended Army interest in rocket experiments for more than 20 years.

"Dr. Goddard eagerly returned to his work on the development of high-altitude rockets, and the following 10 years saw rapid progress. In that fruitful decade he first successfully used liquid fuels for rocket propulsion and developed simple flight rockets powered by this means. He made the beginnings of rocket flight control by gyroscope, the first application of instruments to record conditions on the rocket during

* Reproduced with the permission of the Copyright owner.

† "Associated in this work with Dr. Goddard were H. S. Parker and C. N Hickman, then graduate students at Clark University. Dr. Hickman, in 1940, became one of the principal directors of rocket research and development under the National Defense Research Committee."

# Robert H. Goddard

# —a Biography

***From "Rocket Development," by Robert H. Goddard; Esther C. Goddard and G. Edward Pendray (Eds.), Prentice-Hall, Inc., New York, 1948. Copyright 1948 by Esther C. Goddard.****

flight, and many other significant contributions.

"The period culminated in the rocket flight of July 17, 1929. . . . The importance of this shot was not so much its success as a flight—though within the experimental meaning of the term it was successful—as in the attention it aroused. It led to near disaster and also, through an interesting chain of events, to more adequate support of Dr. Goddard's work.

"The flight of July 17, 1929, was the last of a series of tests conducted at a site on the farm of a relative, Miss Effie Ward, at Auburn, Mass. In his notes Dr. Goddard designated this series thus: 'Test of Medium-Sized Rocket Having High Center of Gravity and Low Center of Air Resistance.'

"The total length of the rocket was 11 ft. 6 in., its greatest width 26 in., and its total weight, empty, about 32 lbs. It was launched from a metal tower 60 ft. high, the rocket being guided up the tower by two $^3/_8$-in. vertical pipes. As propellants, 14 lbs. of gasoline were used and 11 lbs. of liquid oxygen. The rocket carried an aneroid barometer, a thermometer, and a camera focused on both of these instruments, to be operated by a trip lever at the time of ejection of the parachute.

"The rocket fired a total of $18^1/_2$ sec. It rose about 90 ft. above the ground and flew a horizontal distance of 171 ft.

"In this short flight it made a . . . considerable noise—sufficient to alarm the neighborhood. Evidently that July 17 was the kind of day on which sound travels well, for no such attention had been attracted by numerous previous tests at the same spot of approximately equal noise and duration. But on this occasion neighbors sent in calls for ambulances, believing that an airplane had caught fire and crashed. Two police ambulances searched through Auburn for victims. An airplane was sent to investigate. As a result of all this commotion the shot produced an astonishing amount of publicity.

"The sequels are most interesting. One of them was that Dr. Goddard was requested to call on the Massachusetts State Fire Marshal and explain, with the result he recounts in his text. A much happier sequel also occurred. The attention of Col. Charles A. Lindbergh was attracted to Dr. Goddard's work and Colonel Lindbergh brought it to the notice of Harry F. Guggenheim and his father, Daniel Guggenheim. There followed an arrangement for financing the work which made possible his later accomplishments.

"Dr. Goddard's work on the development of rockets falls into four well-defined periods.

"The first, extending from 1899 until after World War I, was one of speculation, mathematical and theoretical development, and experiment with solid-fuel propellants.

"The second, financed by the Smithsonian Institution and Clark University, comprised the years from the end of World War I until . . . July 17, 1929. In this period Dr. Goddard laid the experimental basis for his subsequent work and demonstrated the feasibility of liquid propellants for rockets.

"The third was the period from 1929 to 1941, financed principally by Daniel Guggenheim and later by The Daniel and Florence Guggenheim Foundation, during which the experimenter made great strides in the development and flight of large gyro-controlled, pump-operated liquid-fuel rockets and all but had within his grasp the long-range and high-altitude flights toward which he had been working, the feasibility of which later was so dramatically demonstrated by the Nazis in their 250-mile, 12-ton V-2 rockets.

"The fourth period comprises the time from the beginning of World War II until Dr. Goddard's death on August 10, 1945, during which he worked on important . . . rocket projects at the Naval Engineering Experiment Station at Annapolis, Md.

"The enormous volume of work he accomplished during his lifetime is the more remarkable in view of the fact that he was a lifelong sufferer from tuberculosis, which first became manifest in early manhood. Not only was there ill-health to combat, but he was hampered by lack of sufficient funds during a large part of his productive life. Added to this was the constant skepticism of the technical world generally toward rockets and the sensational, distorted publicity and ridicule that from time to time burst into the press.

"Dr. Goddard was to strangers a quiet, sensitive, scholarly man, reluctant to draw attention to himself. To intimates he was warm, friendly, witty, and unruffled in spite of all obstacles and discouragements. He was an accomplished pianist and enjoyed playing for his own and his friends' entertainment. He was also an artist of ability, painting in both water colors and oils.

"In addition to his active technical imagination and his overwhelming interest in rockets, he possessed two qualities that were of utmost importance in his work. He was persistent, and he was methodical. To the first of these qualities is owed his steady, determined progress in a field so complex that probably no other engineering area exceeds it for difficulty. To the second the world may long be indebted for clear and precise records of everything he did, and a great deal of what he thought, in connection with his chosen field."

---

## "Our Nell"

### *(As Told by Mrs. Robert H. Goddard)*

On July 17, 1929, we had a good flight, with the rocket coming down without a parachute and breaking up on impact, as usual. We hunted for as many pieces as we could find—usually a good percentage, at least of the parts that took a lot of time to make. Just as we were about to pack up to leave, we noticed a cloud of dust on the road above the ravine in which we

*(Continued on page 8)*

**(Reprinted from Aeronautics, December, 1950)**

## "Our Nell"

(*Continued from page 5*)

worked, which turned out to be caused by a caravan of police cars, ambulance, and press cars. Someone had seen the rocket in flight, had mistaken it for an airplane crashing in flames, and had reported it to the police. Later a plane came over to look for "victims." My husband explained what had really happened and begged that the matter be kept out of the papers, but by the time we reached home extras were coming out. My husband issued a short statement as follows: "The test this afternoon was one of a long series of experiments with rockets using entirely new propellants. There was no attempt to reach the moon or anything of such a spectacular nature. The rocket is normally noisy, possibly enough to attract considerable attention. The test was thoroughly satisfactory; nothing exploded in the air, and there was no damage except incident to landing." Nevertheless, the news reports featured a rocket to the moon that had exploded in mid-air.

One of the graduate students who had assisted at the test came into the laboratory next morning quite perturbed and commented: "They ain't done right by our Nell." The name stuck. All during the New Mexico adventure, and afterwards, the rocket was always "Nell," a member of the family. Always too, when there were drinks at a party, no matter whose name was mentioned as being toasted, my husband's eyes sought mine, even across the room, and our drinks were silently for "Nell."

## Goddard Memorial Exhibit Opens

(*Continued from page 1*)

pellants from 1912–1918, showing the culmination in the prototype of the present-day bazooka. The second panel represents the work at Auburn, Mass., with a large photograph of the launching tower at Auburn, as well as one of the first liquid fuel rockets that carried its own weight.

The next period is that in Roswell, N.M. from 1930–1941 and shows the development of instrumentation and control mechanisms with an example of the early use of a simple box camera, thermometer, and barometer as compared to the complicated mechanisms of today. Also included are samples of early parachute releases, gyro stabilizers, and timing devices used at that time. There are numerous examples of combustion chambers showing different cooling devices and methods for injecting fuel.

The next panel illustrates his time at Annapolis from 1941 to 1945 when he was working for the Navy. The material is more scarce here, since a large part of it is still not released, but we do have some examples of different types of oxygen pumps and turbines used in the later liquid fuel rockets. Interspersed in this part of the exhibit are photographs made of the equipment used and also original drawings of designs.

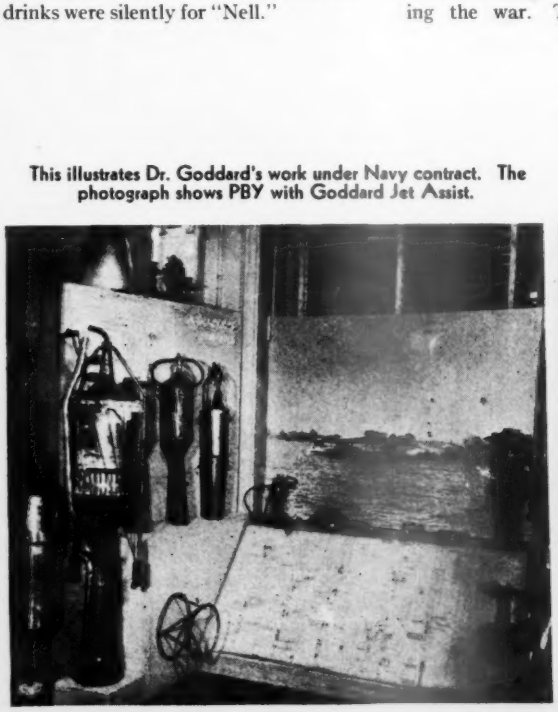
The exhibit is completed by a panel showing pictures of the German V-2's and the damage they did in London during the war. The V-2's incorporate many of the ideas and basic theories of Dr. Goddard.

In addition to this material, Reaction Motors has added a panel to help bring the collection up to date. This shows a modern rocket engine as used in the Bell X-1 and the Douglas Skyrocket. The U.S. Navy will add to the exhibit with a JATO panel.

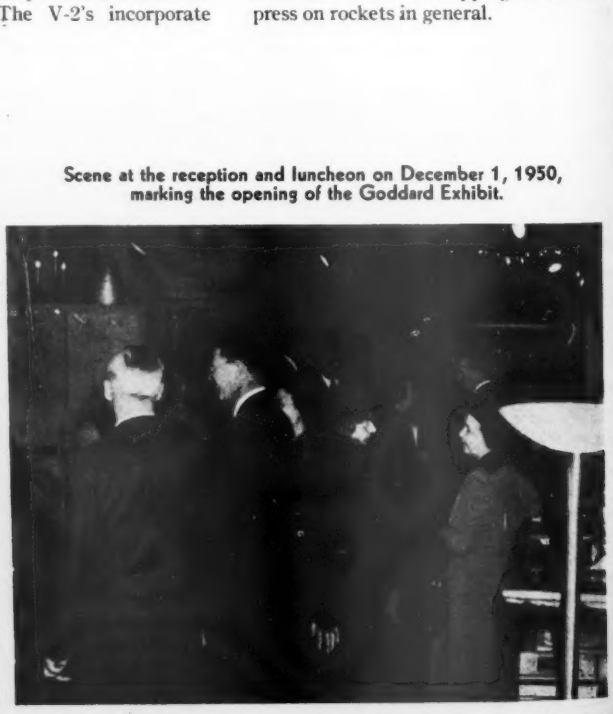
Dr. Goddard's collection of books and articles on rockets and jet propulsion, included by Mrs. Goddard in the gift, contains more than 250 items, including writings on aerodynamics, liquid oxygen, materials, meteorology, and other topics related to rocket design and rocket flight. There are items in English, French, German, and Russian, including such authors as Robert Esnault-Pelterie, Willy Ley, Hermann Oberth, N. A. Rynin, Eugen Sänger, and K. Ziolkowsky. A number of reprints from such journals as *Maschinenkonstrukteur-Betriebstechnik*, *Auto-Technik*, *Recherches et Inventions*, *Journal de Physique*, *Astronomische Rundschau*, and *Der Zeitungs-Kosmos* were not previously in the I.A.S. Libraries.

Reprints of Dr. Goddard's own papers are also included. These are supplemented by nine volumes of clippings covering Dr. Goddard's rocket activities as reported in the press from 1904 until his death in 1945, with later comments in the press up to 1949. There is a tenth volume of clippings from the press on rockets in general.

**This illustrates Dr. Goddard's work under Navy contract. The photograph shows PBY with Goddard Jet Assist.**



**Scene at the reception and luncheon on December 1, 1950, marking the opening of the Goddard Exhibit.**



**(Reprinted from Aeronautics, December, 1950)**

*Management's problems in the industrial era begun by man's initial ventures into space are pictured as both numerous and varied. The author predicts an "interesting and vexing" period before solutions are obtained.*

# The Space Age Effect on Management

Edward A. Ledeen
Curtiss-Wright Corporation

SPACE FLIGHT, which became a reality on October 4, 1957, has produced as pronounced an effect on the aviation industry as did the successful detonation of the first atomic blast on the ordnance field. Because the first successful satellite launching was achieved by the U.S.S.R., national prestige had to be enhanced by attainment of future space "firsts." Toward this end, Dr. Killian was appointed Scientific Adviser to President Eisenhower, the lunar probe program was accelerated, and the research and development activity, previously curtailed, was increased substantially. Other steps followed—NASA, ARPA, etc.

Complexity was already a problem before Sputnik I, but it grew in the space age. Coupling the complexity of instrumentation, propulsion systems, control devices, and airframe with the weapons systems concept of procurement has made it difficult for any one airframe manufacturer to undertake development as the prime contractor. This problem is faced by formation of a "team" of contractors. Part of the problem is the character of the personnel required. Willis Hawkins of Lockheed Missile Systems Division has previously noted that 44 different research specialists are needed in the airplane business, and this new space business requires 63 different research specialists.

Continuity in employment of technical personnel is another facet of the problem. Most of the engineering managers of the "space flight" divisions are of the opinion that this portion of the industry will never grow to be "big business" in terms of large production orders (as we knew them during World War II), but that the emphasis will continue to be on research and development.

Great effort will be needed in the applied sciences. Missile manufacturers will team up with basic research groups, such as universities, to provide a combination of capabilities to meet the demands imposed by this new giant. Propulsion systems, guidance systems, materials development are but a few of the areas requiring substantial research. Government sponsorship of research in these and other fields of technology is required on a continuing—not a one-shot—basis.

New sciences, such as magnetohydrodynamics, have come into being in recent years and will have a pronounced effect on the basic curriculum of our engineering colleges and technological institutions. Where it was possible, in previous years, to provide the undergraduate student with sufficient academic training to equip him to take a place in industry upon completion, the demands for personnel with advanced degrees are making the graduate study programs of major importance to the faculties of our institutions of higher learning. Industry has taken cognizance of its needs for personnel with advanced degrees, and many companies have instituted tuition-assistance programs permitting their employees to augment their education and increase their ability to perform the assignments which face them in this advancement of the state-of-the-art. These tuition-assistance programs are in addition to the many fellowships, in-plant training programs, and other training devices utilized to increase the efficiency and technical ability of their staffs. In case some one takes me to task for mentioning the contributions that industry is making to meet the situation, it must be emphasized that all the branches of the Armed Services have been doing the same thing for many years. I have had experience with the extension work done at Wright-Patterson AFB by Ohio State University in conjunction with the Air Force to permit civilian, as

*(Continued on page 58)*

---

**These comments constitute the author's remarks opening the panel discussion on "The Space Age Effect on Management," of which he was Session Chairman, at the IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959. (The four papers comprising this Session are available as IAS Report No. 59-61.)**

**Mr. Ledeen is Staff, Engineering Operations, Wright Aeronautical Division.**

*The cone-sphere body has been studied in hypersonic helium flows at Mach Numbers of 22 and 25. The relations between the shock wave and the body were obtained for a series of cone-sphere models with bluntness varying from that of a flat-ended circular cylinder to a hemisphere-cylinder. The experiments have shown that the flow field may be approximated by either the simple sphere flow or the flat circular disc flow within determined ranges of cone-sphere bluntness.*

# The Cone-Sphere in Hypersonic Helium Above Mach 20

Robert H. Johnson
Research Laboratory
General Electric Company

THE FAMILY of aerodynamic body shapes made from blunting the apex of cones with spherical surfaces is typical of shapes that will be of use on hypersonic vehicles requiring high drag. The drag force and the location of the center of pressure on these bodies may be varied by changing either the cone-angle or the relative radius of the spherical nose. The results of experiments or analysis on these shapes may be applied to a large variety of similar bodies. These results involve the relation between the detached shock-wave shape and the body.

The experimental work reported here was done with the hypersonic helium tunnel in the General Electric Research Laboratory (cf. Figs. 1 and 2).[1] The test runs were made at Mach Numbers of 21.6 and 25.7 and at test section pressures of the order of 2 mm. Hg. The use of helium gas as the working medium for the tunnel allows the extremely complex flow field of a real gas to be simplified.[2] That is, only the purely aerodynamic aspects of the flow caused by the dynamic and viscous characteristic of the gas are considered. The real gas effects are not accounted for in the helium analogy for hypersonic flow. The inlet stagnation pressure in the tunnel was held between 3,940 and 3,995 psia giving a free-stream Reynolds Number per inch of approximately $0.79 \times 10^6$.

## Measurements

This paper will present the geometric relation between detached shock waves and a series of cone-sphere bodies of varying bluntness from a hemisphere-cylinder to a flat-ended cylinder. The cone vertex half-angle was varied from 0° to 90° resulting in a family of bodies shown in Fig. 4 where $\theta$ is the complement of the cone half-angle. The cone base radius and nose sphere radius were kept constant at a ratio of three.

Measurements of shock-wave geometry were obtained from schlieren photographs taken during test runs with each model configuration. These photographs are shown in Fig. 3. Only the stronger density gradients are visible with a schlieren system in the helium tunnel. This is because of moderately low test section densities and the low index of refraction of helium. The strong detached shock wave may be clearly seen, as well as the density gradient of the re-expansion in the shock layer of the more blunt models.

## Centerline Detachment Distance

The shock-wave detachment distance along the centerline has been computed by many workers.[3-6] The large entropy gradients and rotationality in the shock layer has required most theoretical treatment of the blunt body to be confined to a region very close to the stagnation point. The results of most of these investigations thus yield only a centerline detachment distance and other flow properties near the stagnation point. Numerical methods have, however, been used

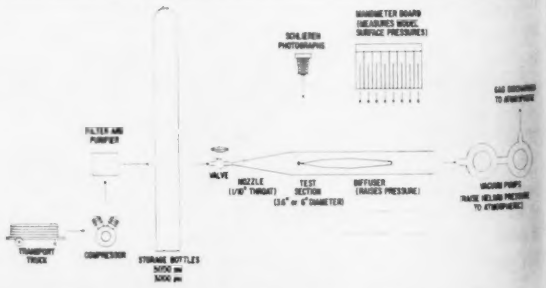



FIG. 1. Schematic diagram of the helium tunnel.

**This paper was presented at the Aerodynamics I Session, IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959. It was originally part of a doctoral thesis at Rensselaer Polytechnic Institute, Troy, N.Y. The work was supported by the Ballistic Missiles Division of the Air Force. (The complete article is available as IAS Report No. 59-2.)**

**Dr. Johnson is a Mechanical Engineer, Mechanical Investigations Section, Chemistry Research Department.**

to predict some of the details of the complete flow field[6] and now show the most promise for obtaining good analytical treatment of the problem.

The centerline detachment distance $\delta$ was measured for all models and plotted on Fig. 4 as a ratio of nose sphere radius $R_s$ against $\theta$. These results show that the shock-layer flow field may be divided into three regions designated in this paper as I, II, and III and characterized by marked differences in detachment distance and in shock-wave shape.

The curve of detachment ratio $\delta/R_s$ shows the manner in which the shock-layer flow field varied between the flat circular cylinder and the sphere flow. The detachment distance in region I remained nearly constant at the sphere value from $\theta = 90°$ to a cone-sphere with $\theta = 39°$. The theoretical values of Heybey[5] and Serbin[3] are shown for comparison with this and for the flat disc value for $\theta = 0$. In the latter case, the detachment ratio was formed with the cone radius $R_c$.

The correlation for both cases, hemisphere and flat-ended cylinder, is satisfactory, indicating that the detachment distance theory is good for these simple bodies in hypersonic ideal gas flow. The theory for the flow about more complex bodies is not as good.

Bodies with sphere-to-cone tangency angles smaller than the presumed sonic point angle ($\theta^* = 43°$) still exhibit sphere body flow characteristics. This indicates the possibility that the sonic point might have migrated forward. The sonic point on the spherical portion of the sharper bodies appeared to have been forced upstream from the value predicted and measured on the complete hemisphere. That is, the Newtonian approximation gives $\theta^* = 45°$, and the measured pressure distribution (cf. reference 7) yields $\theta^* =$

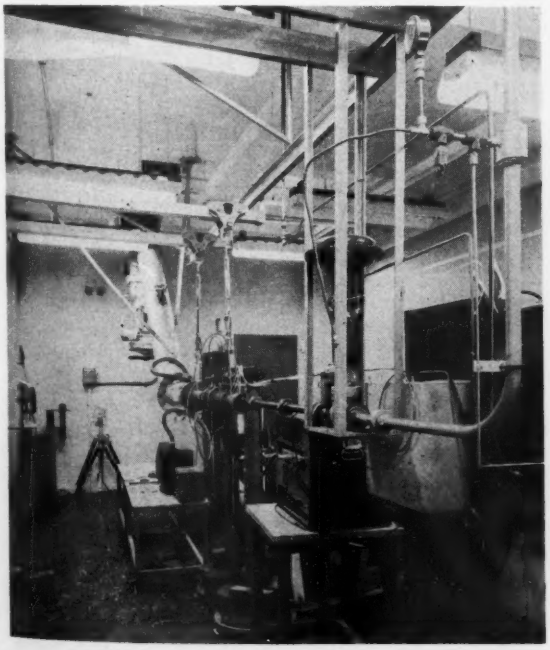


FIG. 2. Helium tunnel apparatus.

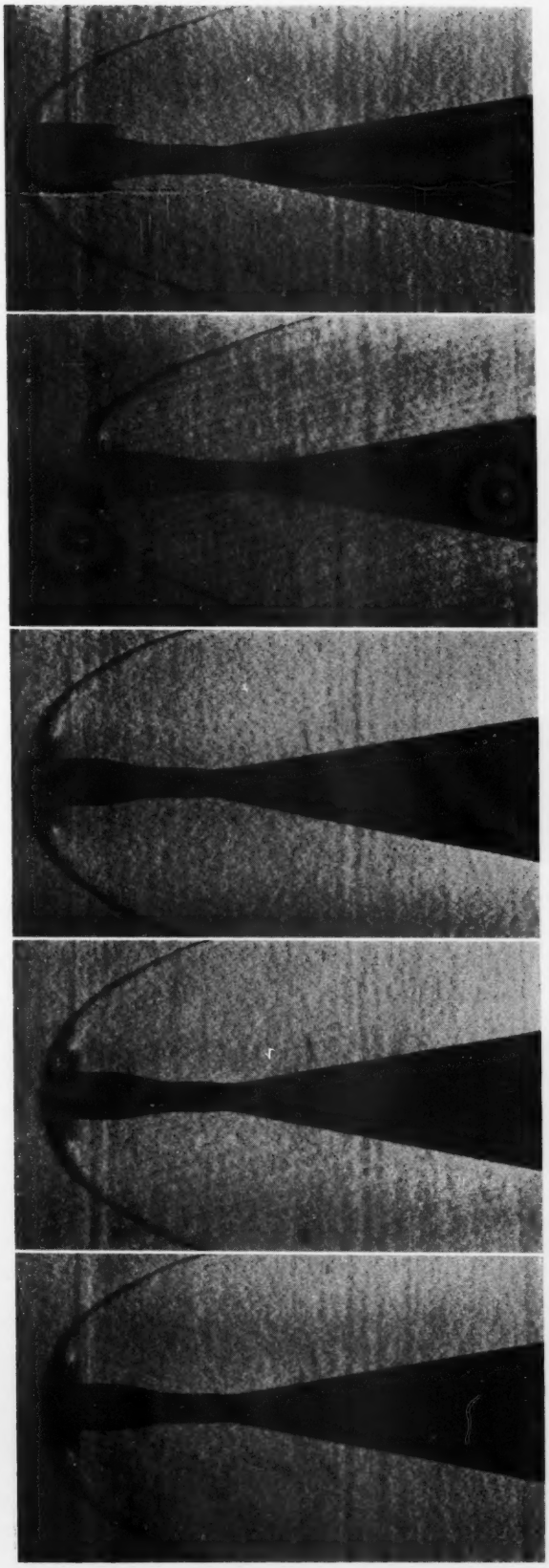


FIG. 3. Schlieren photographs of cone-spheres in helium at $M = 22$. *Top to bottom:* (a) $\theta = 0°$; (b) $\theta = 10°$; (c) $\theta = 15°$; (d) $\theta = 20°$; (e) $\theta = 30°$.

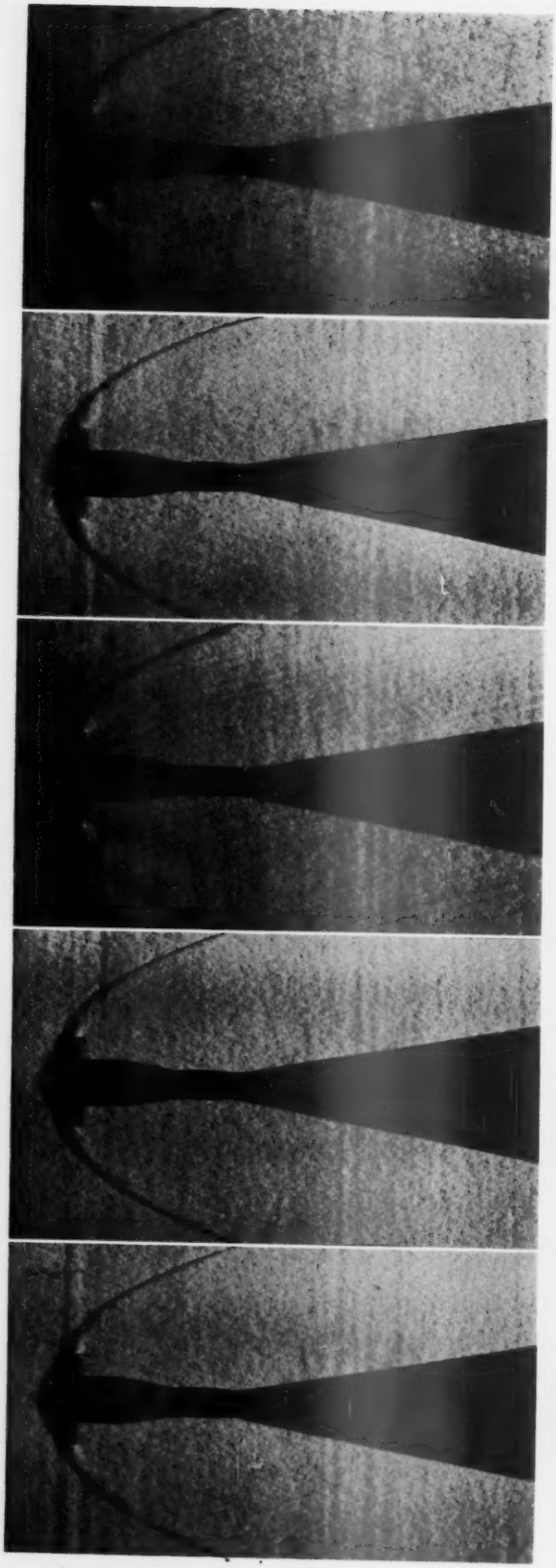


FIG. 3 (*cont'd.*). *Top to bottom:* (f) $\theta = 35°$; (g) $\theta = 38°$; (h) $\theta = 40°$; (i) $\theta = 41°$; (j) $\theta = 45°$.

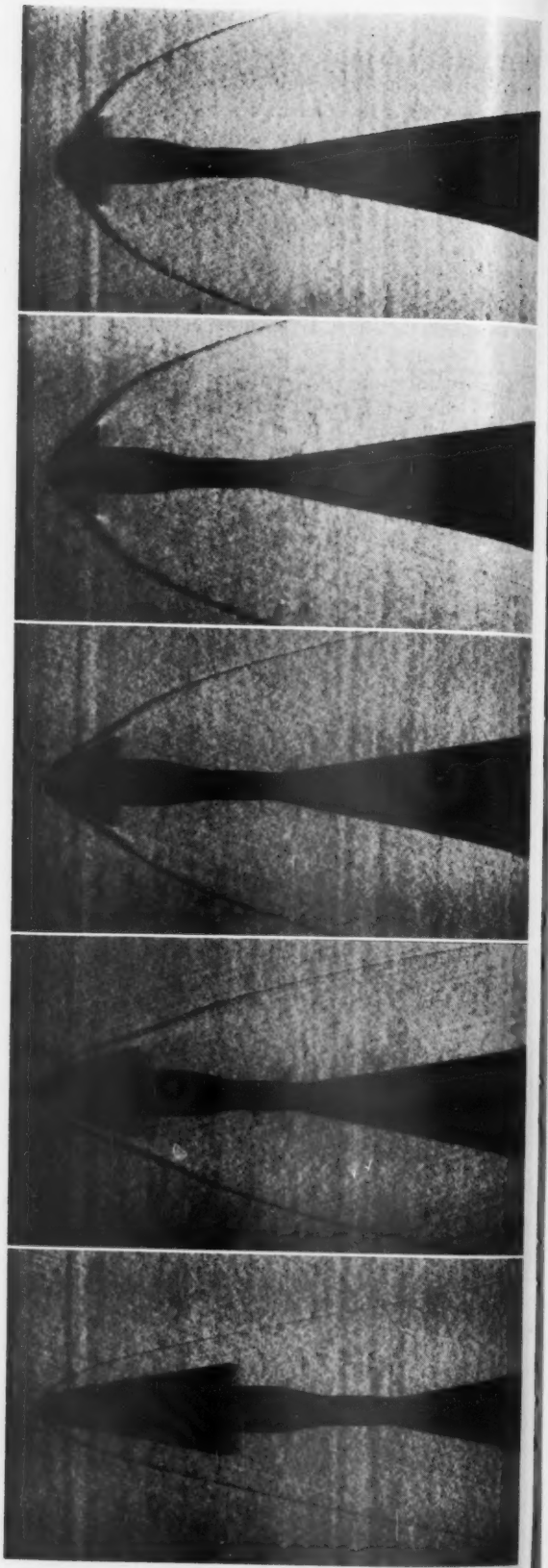


FIG. 3 (*cont'd.*). *Top to bottom:* (k) $\theta = 47.5°$; (l) $\theta = 50°$; (m) $\theta = 60°$; (n) $\theta = 70°$; (o) $\theta = 80°$.

43°. This forward migration is postulated because of the fact that when $\delta/R_s$ finally increases with $\theta$, it does so abruptly (as if the body sonic point moves rapidly outward in the radial direction with decreasing $\theta$). Thus, one would be led to believe that the sonic point remained on the spherical part of the bodies in group I (Fig. 4). In other words, the cone section behind the spherical surface causes the gas to accelerate more rapidly, making the sonic location occur further upstream.

A rather sharp transition in the shock-layer flow field manifested by the abrupt change in detachment distance from the sphere value to the flat cylinder value has been observed. The bodies in group III show characteristics of the flat-ended cylinder flow. The $\delta/R_s$ data did not plot well for values of $\theta$ less than 20°. This is not surprising because there is very little spherical surface left on these bodies. Hence, if an axial distance $D$ between the shock wave and the plane of the base of the cone were plotted instead of $\delta$, a reasonable model of the flow about this group of body shapes may be deduced. This plot is shown in Fig. 5 where the axial distance $D$ was normalized with the constant outside radius of the model $R_c$. The values of $D/R_c$ remained quite constant from $0° = \theta$ to about 20°. It is concluded from this that the sonic point was located at the base of the cone for the blunt group of body shapes. Thus, for $0° = \theta < 20°$, the shock-layer flow about cone-sphere shapes may be considered that of the flat circular cylinder flow.

The present results thus allow prediction of the detachment distance for a wide range of cone-sphere bodies with the use of the simple body theories. That is, for ideal monatomic gas, the sphere theory may be used for bodies where $\theta > 39°$ and the flat-ended cylinder theory for bodies where $0° = \theta < 20°$. Only in region II where $20° < \theta < 39°$ will the complete body geometry have to be considered for predicting the detachment distance for cone-sphere bodies.

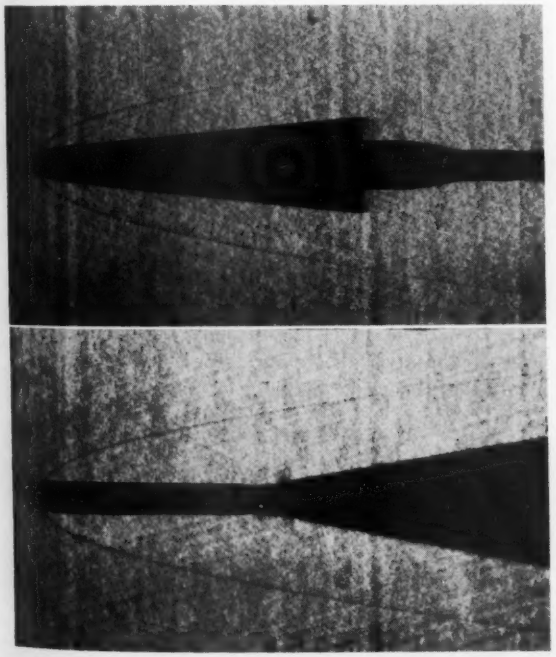


FIG. 3 (*cont'd.*). *Top to bottom:* (p) $\theta = 85°$; (q) $\theta = 90°$.

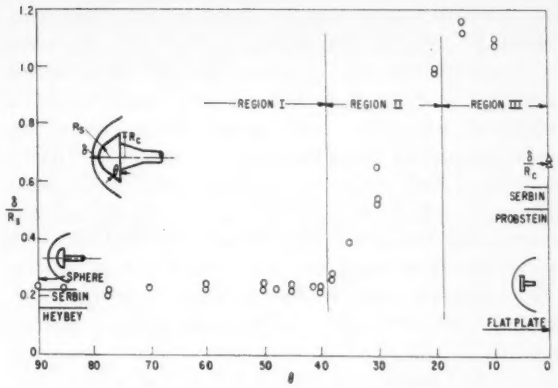



FIG. 4. Centerline detachment distance.

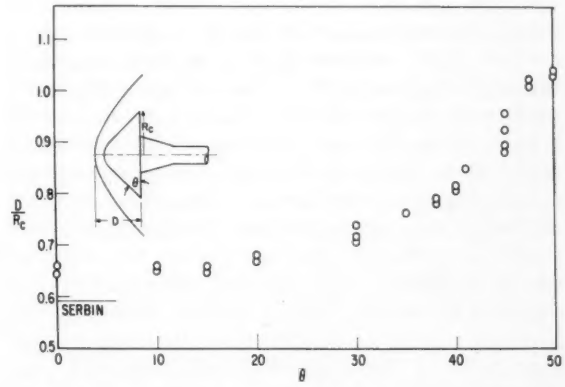



FIG. 5. Shock-wave position for very blunt cone-spheres, $M = 22$.

## SHOCK-WAVE SHAPES

The shock-wave shape also tended to fall into the three groups. For the more blunt bodies [region III where $\theta = 0°$ to 20° on Fig. 3 (a), (b), (c), (d)], the shock-wave shape was monotonic. In the range $20° < \theta < 39°$ [region II and shown on Fig. 3 (d), (e), (f), (g)], a portion of the shock exhibited an increasing tendency toward a conical shape—i.e., a small segment of the shock had a straight line profile. Also in this range of body shapes, the detachment distance varied considerably with body cone angle. The models with $\theta > 39°$ (region I) show a definite portion of the shock wave to be conical in shape, indicating a conical flow over all or most of the cone surface. This flat portion of the shock wave cannot be seen on the sharper bodies because the Mach angle was so small that the disturbance from as far forward as the cone-sphere tangency point did not intersect the shock in the field of view of the test section windows.

If the flow along the cone surface were purely conical,

the pressure would remain constant along any cone element.[8] That is, the gradient $dp/ds = 0$. However, if this were the case, a discontinuous change in the detachment distance and shock-wave shape would be observed when the sonic point jumped from the spherical surface out of the base of the model. That is, a discrete state of the gas could not exist on the cone. However, a finite slope of the curve of $\delta/R_s$ has been determined from the measurements (cf. Fig. 4). The transition from what we have called sphere flow to the flat-ended cylinder flow occurred over the finite interval $20° < \theta < 39°$. Also in this region a gradual change in the shock-wave shape occurred from the monotonic surfaces of region III to the conical segmented shock shapes of region I.

The fact that the transition between sphere and flat plate flow did not occur discontinuously, but occurred over a finite range of body shapes, might lead one to conclude that a pressure gradient of finite magnitude existed on the cone surface. This effect may be attributed to the rotational flow produced by the curved detachment shock wave. The conical flow demands a conical shock wave, but the blunt nose sphere requires a curved detached shock wave. The reflection of disturbances from the curved shock intersecting the body resulted in a finite pressure gradient on the cone portion of the body. Thus, the sonic point may become stabilized on the cone surface. In fact, it is concluded here that, in at least part of region II, the location of the sonic point on the cone surface will vary with cone angle $\theta$.

The density variation along the cone surface of the more blunt models may be seen on the schlieren photographs of Fig. 3. A change in light intensity was observed on the cone part of the surfaces of models (b) through (l) indicating a variation in density.

## Discussion

The cone-sphere investigation has shown the possibility of being able to group many bodies in a "spherical flow" class and others in a "flat-ended circular cylinder flow" class. Information such as the approximate shock-layer thickness and perhaps the body pressure distribution may be obtained without the need of a complete analysis or an experiment if the body may be so classified.

The quantitative results of aerodynamic investigations made in hypersonic helium are not directly applicable to a comparable flow in air because of the real gas effects. However, a direct quantitative correlation with "perfect gas" air can be made by considering the difference in the physical properties of the two gases.[2]

One result from the cone-sphere experiments may have a direct application in studies involving real gas effects. The fact that the detachment distance has a strong dependence on the model geometry in region II (cf. Fig. 4) suggests a method for determining the amount of excitation of the internal degrees of freedom of a gas. If a small change in geometry causes such an appreciable change in shock detachment distance, one would surmise that a change in the gas properties will also change the shock detachment by an appreciable amount. The degree of vibrational excitation of chlorine gas has been measured by determining the change in the detachment distance of a sphere fired into the gas.[9] A relatively small (20 per cent) change in the sphere detachment distance indicated full excitation of vibrational degrees of freedom of the chlorine. The advantage of using a body in region II for making this measurement would be that the same percentage change in detachment distance would represent a larger measurable dimension. Thus the sensitivity of the experiment would be increased. The experiments in reference 9 presumed immediate equilibrium. However, if the relaxation time were excessive in the transition being measured by detachment distances, the measurements would be meaningless. Thus, the usefulness of the method would depend on the given situation—i.e., those properties affecting relaxation time.[10]

The possibility of greater aerodynamic stability of bodies having the geometry of region II has been suggested by the present experiments. The shock-wave detachment distance and bluntness (strength) increases rapidly with increasing body bluntness. Thus if the body should yaw, the shock strength difference between the low- and high-pressure sides would be greater for the region II bodies. The restoring pressure difference on the body surface will thereby be maximized, tending to decrease the yaw angle. The circumferential flow induced by the asymmetry will tend to minimize this effect; however an improvement in body stability of some finite magnitude will be achieved.

A few bodies in each group were rerun in the helium tunnel at Mach Number 25.7 with the same inlet stagnation pressure. No measurable change in shock-wave geometry was observed. The detachment distance relationship with cone-sphere sharpness was the same as the Mach Number 21.6 results reported in this paper.

The values of $\delta/R_s$ for some of the models in groups I and II are very close to those taken from a recent paper by Bogdonoff and Vas.[11]

Many schlieren photographs have been included as part of this paper since they represent the source of the data. Also, since the conditions of the experiments are somewhat unique, they are presented here in the hope that other investigators may find them of use, especially as physical boundaries for the further development of the theory of "perfect gas" hypersonic flow.

## References


[1] Johnson, Robert H., *Hypersonic Helium Tunnel for Operation Above Mach Number Twenty*, G-E Research Lab. Report No. 58-RL-2089, 1958.

[2] Bogdonoff, S. M., and Hammitt, A. G., *The Princeton Helium Hypersonic Tunnel and Preliminary Results Above M = 11*, Princeton University, Dept. of Aero. Eng., Report No. 260, 1954.

[3] Serbin, Hyman, *Supersonic Flow Around Blunt Bodies*, Journal of the Aeronautical Sciences, Vol. 25, No. 1, pp. 58, 59, Jan., 1958.


(*Continued on page 53*)

*Speculation leads to theory and theory culminates in achievement.*
*This permits, even demands, that we join*
*in the "significant pleasure of speculation" about the future of propulsion.*

# Prophecy for Propulsion—One Man's Guess

T. F. Dixon
North American Aviation, Inc.

THERE IS RISK in speculation. Possibilities for error are enormous. Not only are extrapolations from existing development and trends likely to be miscalculated, but the future of rocket propulsion depends, in large part, on factors which are nontechnical in nature—factors of more pertinence to the statesman, the staff officer, and the economist than to the engineer. However, engineers, like everyone else, enjoy the attempt to predict the weather of the future. Consequently, I propose my forecast for propulsion. Consider it as an invitation, not to agree, but to join with me in the significant pleasure of speculation.

Figs. 1 and 2 in my article state some propulsion requirements for certain space missions. Fig. 3 lists some characteristics of propulsion systems pertinent to the following discussion. Fig. 4 presents a possible engine development schedule.

## Liquid-Propellant Rocket Engines

Chemical engines in their current state of development cannot attain 300 sec. of sea-level specific impulse. This means that extremely heavy missiles and high propellant consumption will be required for most space missions. However, theoretically, specific impulses 25 per cent greater than those obtained now will soon be possible with the development of new high-energy chemical propellants.

Two future engines are close neighbors to the present. One of these propulsion systems is a 1,500,000-lb. cluster and the other is a single-barrel unit with a thrust range between 1,000,000 and 1,500,000 lbs. (see Fig. 5).

The 1,500,000-lb. cluster (see Fig. 6) will package several engines, the components of which today are standard in operational missiles. This utilization of existing components will reduce development time and save money. The cluster will be capable of placing a 5-ton payload in a 22,400-mile earth orbit or landing a 1-ton payload on the moon.

A 1,000,000-lb. single-barrel rocket engine demands no technological breakthroughs. It will constitute, however, the most significant advance in propulsion since the development of the V-2 rocket. A 1,000,000-lb. engine is capable of placing a 20,000-lb. manned satellite into orbit or sending a 5,000-lb. vehicle from

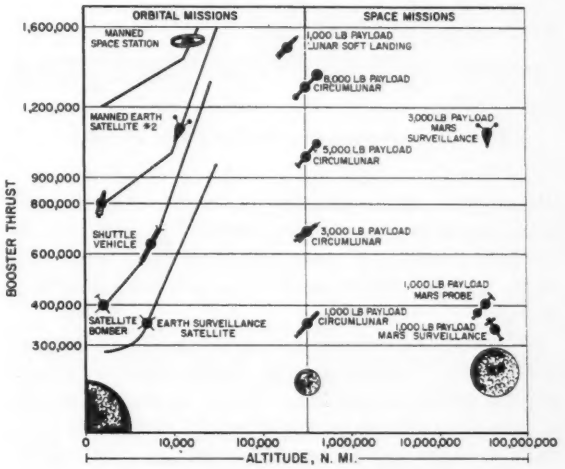



FIG. 1. Space mission thrust requirements.

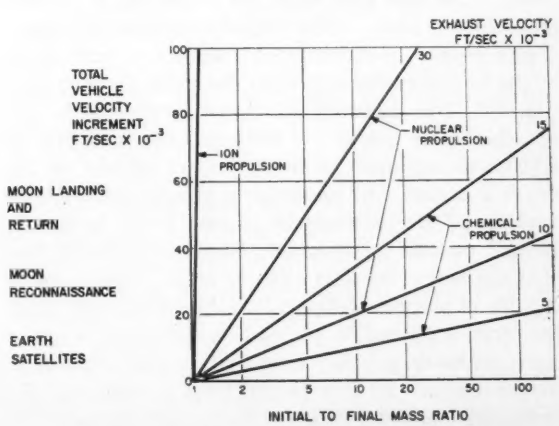



FIG. 2. Additional space mission requirements.

Mr. Dixon is Chief Engineer at Rocketdyne, a Division of North American Aviation, Inc.

This article is based on "A Look at Rocket Propulsion for the Next 25 Years," a paper presented at the Propulsion II Session (available as IAS Report No. 59-54), IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959.

| ENERGY SOURCE | TYPICAL WORKING FLUID | MAXIMUM TEMPERATURE F | SPECIFIC IMPULSE, ALT SEC | THRUST/ENGINE WEIGHT | VEHICLE ACCELERATION G'S |
|---|---|---|---|---|---|
| CHEMICAL PRESENT LIQUID PROPELLANTS | LOX/RP | 5700 | 280 | 50/100 | 1.2–1.5 |
| HIGH-ENERGY LIQUID PROPELLANTS | $F/H_2$ | 7900 | 400 | 50/100 | 1.2–1.5 |
| NUCLEAR | $NH_3$, He, $H_2$ | 6000 | 1000 | 10/50 | 1.2–1.5 |
| ION | Cs, Rb | – | 5000–20,000 | .0005/.00005 | .0001 |
| THERMONUCLEAR | DEUTERIUM TRITIUM | – | 20,000 | – | – |

FIG. 3. Characteristics of propulsion systems.

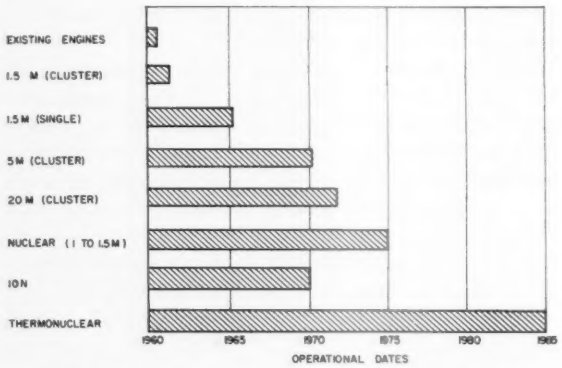



FIG. 4. Theoretical engine development schedule.

the earth to another planet. Naturally, when this unit is clustered, our power range will be extended to encompass a variety of even more formidable space missions. A 1,000,000-lb. engine can be operational in 6 years.

Following the technological triumph of such engines, it is logical to suppose that still greater propulsion projects will be undertaken. Within 15 years, it should be possible to develop a single-barrel 5,000,000-lb. unit. Such an engine will be capable of placing a 260,000-lb. payload in a low orbit or a 50,000-lb. payload on the moon. The next step would be to develop a 20,000,000-lb. powerplant. This could be achieved by a four-engine cluster of 5,000,000-lb. engines, a feat which might be accomplished within the next 25 years (see Fig. 7). The 20,000,000-lb. thrust level could be approached more quickly by clustering ten to twelve 1,500,000-lb. engines. Such engines are already on the drawing boards, and prototype components have been developed. To cluster such engines would be an expedient method for obtaining close to 20,000,000 lbs. of thrust within the next 15 to 20 years. This thrust is capable of placing a 300,000-lb. payload in a low satellite orbit, a 200,000-lb. payload on the moon, or orbiting a 60,000-lb. payload around Mars and returning it to the earth. Such a thrust level is sufficient for propelling manned vehicles to the moon and Mars.

However, Scott Crossfield is still a long way from the moon. Enormous development effort is essential before super liquid-propellant rocket engines become practical tools of space flight. Such engines almost require us to revise our conceptions of research and development. For example, they would tear existing test stands up by the roots. It is hard to conceive of engines of such force. Turbopumps would produce the power output of small cities. Combustion chambers would have combustion densities multiplied many times beyond those of existing engines. New ranges of difficulty will be revealed in tank structure, pumps, feedline controls, etc. Heat transfer problems and the dangers of combustion instability will assume new dimensions. These super engines may have to be assembled and tested, if not fabricated, at the launch site, and in much the same way as ships are built in the shipyards from which they are launched. In spite of these considerations, such engines are entirely feasible. Moreover, they are obtainable within a few years. However, I have not said "easily" obtainable. As a philosopher once remarked, all things excellent are as difficult as they are rare.

## Nuclear Engines

An operational nuclear engine would constitute a monumental step in space propulsion. Moreover, it seems to be a necessary step. Chemical and physical laws set the energy limit of liquid-propellant engines (utilizing conventional chemicals) at approximately 400 sec. of specific impulse.[1] For many space missions, a performance in excess of 400 $I_s$ is necessary.[2] [Figs. 8(a) and 8(b) show the performance of a nuclear rocket using heated hydrogen as the propellant. 8(a) represents (frozen equilibrium) sea-level and altitude specific impulse at a chamber pressure of 500 psi. 8(b) shows altitude (shifting equilibrium) specific impulse for a reactor temperature of 5,400°F.]

While proposed nuclear engines appear to be about the same size as proposed chemical engines, the engine $I_s$ of the nuclear system results in a smaller propellant consumption, and, consequently, permits an improvement in vehicle gross weight and mass ratio. A typical nuclear engine (see Fig. 9) uses a gas-cooled solid reactor with a nuclear heat source placed in the combustion chamber where heat is generated by the fission of U-235.[3] The configuration of this reactor depends mainly on heat transfer, neutronic, and structural considerations.[4–8] The elements of the reactor are the core, the reflector, the support structure and pressure shell, and the controls.[3,9–11]

Thermal energy is generated by heating a single liquid propellant in a high-temperature solid-fuel-element reactor core.[8] From the standpoint of molecular weight and working temperature, hydrogen, with a weight of two appears to be the most promising propellant.[5,12–14] The fact that $I_s \propto \sqrt{T/m}$ shows the importance of low-molecular-weight gas to high performance.

Before entering the reactor core, the working fluid

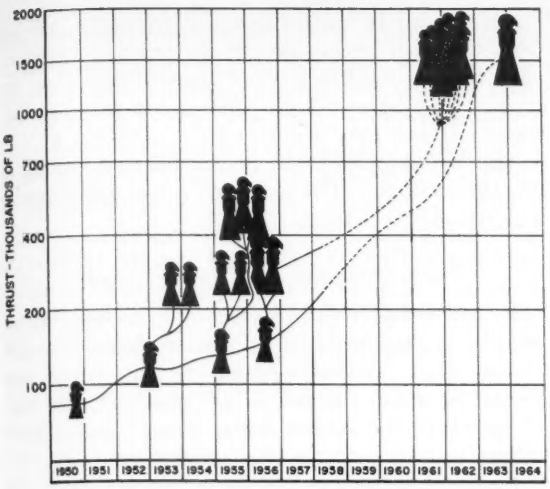



FIG. 5. Large rocket engine development trends.

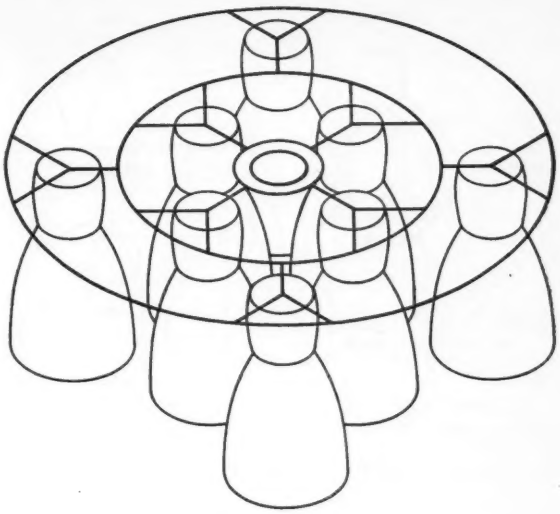


FIG. 6. Multiple engine cluster.

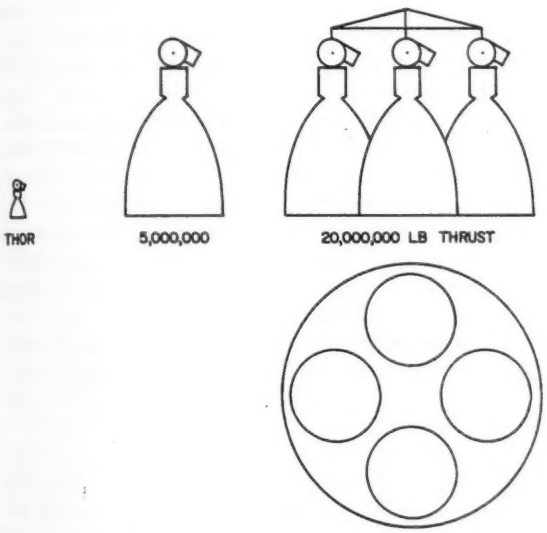



FIG. 7. Size ratios of large-thrust chemical engines.

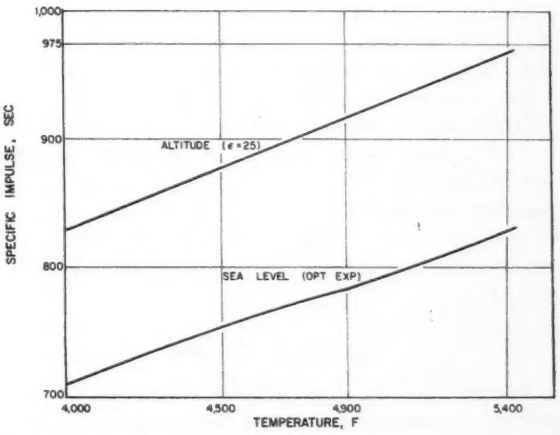



FIG. 8(a). Specific impulse (frozen equilibrium) of $H_2$ in nuclear rocket with chamber pressure of 500 psi.

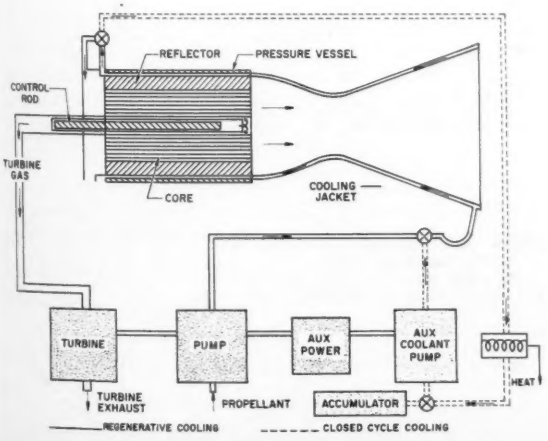



FIG. 9. Dual thrust nuclear rocket.

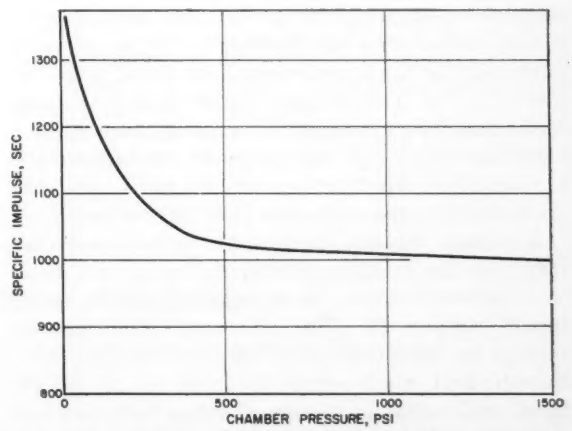



FIG. 8(b). Altitude specific impulse (shifting equilibrium) of $H_2$ in nuclear rocket with reactor temperature of 5,400°F.

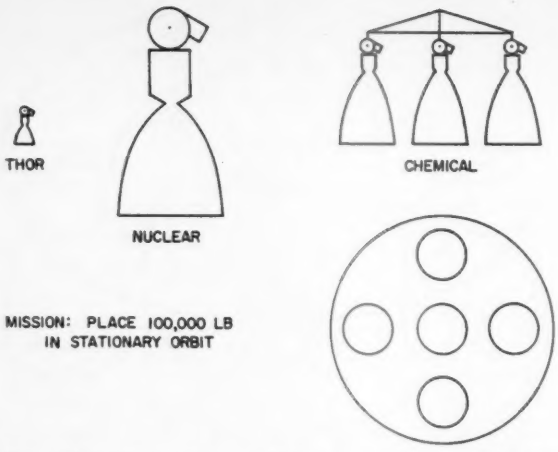



FIG. 10(a). Comparison of high-energy systems (stationary orbit).

leaves the propellant tank by means of the propellant pump. It is divided into two streams. One stream flows through the cooling jacket and cools the nozzle, reflector, and pressure vessel prior to entering the reactor core. The other stream cools the control rods, structural supports, etc., in the reactor prior to entering the core. A portion of the second stream is diverted to a section of the reactor where it is heated to the temperature necessary for turbine operation.

The nuclear rocket engine will probably become operational during the time period likely to be dominated by the super liquid-propellant rocket engines discussed previously. [Figs. 10(a) and 10(b) present a size comparison of these engine types for two missions.]

## ION ROCKET ENGINE

Another promising propulsion system is the ion rocket, a system in which the exhaust jet is electrostatically accelerated.[15] The ion rocket is in development now and will be available in 5 to 10 years, depending on the degree of effort expended.

The ion rocket engine is essentially a simple device (see Fig. 11). It consists of an ion source with one accelerating electrode for the ions and another accelerating electrode for the electrons.[16] The propellant is carried in the most convenient form (solid, liquid, or gas) and is fed through a feed system where it is vaporized, after which it enters an ionizing chamber at a controlled rate. A reactor-power turbogenerator, or, possibly, a direct conversion unit, will supply electrical energy to the accelerator grids and the ionizer.

A strong, negative electrostatic field extracts the ions from the ionizing chamber and accelerates them to a suitable velocity, producing the engine's major thrust component. The electrons, after passing through the generator, are emitted into a positive electrostatic field, which accelerates them into the ion exhaust trail. This is necessary because both ions and electrons must be ejected to maintain an electrically neutral vehicle.

Because of its small thrust-to-weight ratio, the ion rocket literally cannot get off the ground. However, once boosted to altitude by a chemical or nuclear engine, it may be used for a variety of interorbital missions. It will also, via hyperbolic paths, be able to escape into deep space and pass in the near vicinity of the outer planets. The ion rocket has unusual promise as a research vehicle.

## THERMONUCLEAR AND PLASMA ENGINES

In the low-gravity space of interplanetary flight, engines may operate with very small thrust-to-weight ratios. Thus, relatively heavy equipment can be used to exhaust small amounts of propellant at very high energies. In this regard, fusion engines appear interesting.[17]

If controlled fusion is realized in the near future, the thermonuclear engine may be in early development stages in about 25 years.[18–20] There are several approaches to thermonuclear propulsion. In one plasma system, shock waves or other means are used to excite deuterium or tritium to its ionization potential. In this state, the electrical conductivity of the gas is greatly increased by the free electrons. It is therefore possible to raise the energy level of the gas with electromagnetic forces until fusion energy is achieved. Once fusion takes place, radiation losses are removed through a coolant which serves as a secondary propellant. The coolant is mixed with the charged reaction products and the mixture is exhausted with the propellant. Theoretically, it is possible to obtain a specific impulse between 1,000 and 100,000 sec.[17]

One of the attractive possibilities of this engine is its capacity to be self-operative with a minimum of out-

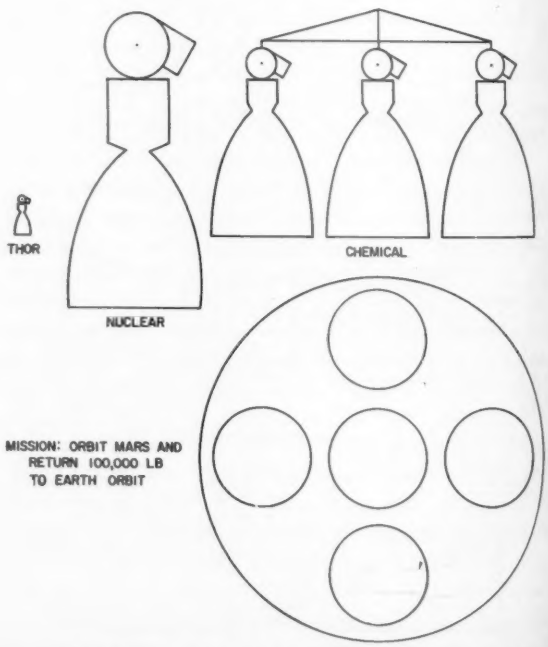



FIG. 10(b). Comparison of high-energy systems (Mars mission).

side electromagnetic energy. The useful power resides in the charged particles which are contained by the magnetic field. After the magnetic field has excited the plasma to reacting temperature, the reacting and expanding plasma should act as a generator and put a significant portion of the energy it possesses back into the electrical storage system.

Another possible system is one in which a pseudo-neutral gas plasma is created at temperatures between 20,000 and 50,000 F. This is a momentum flow system—i.e., the flow results from the plasma's momentum. The specific impulse of this system should be somewhat less than that of an advanced ion system. However, its thrust level should be an order of magnitude higher. A small engine of this type could probably be developed in a few years. Even a larger, long-lived, reliable system with a high specific impulse might be developed within less than 10 years. Such a propulsion system would be attractive if an extremely lightweight power plant could be produced for generating the necessary electrical power.[21]

The "push-pull" system is another plasma propulsion device. Fission plasma is made critical in a pulsating fashion so that high temperatures and pressures are generated for short durations. Consequently, while tolerable average temperatures and pressures are maintained, energy is generated for heating a secondary propellant gas.[22] The cycle consists of a series of oscillating shock waves produced by the alternate criticality of either end of a cylindrical system.

With regard to these last-discussed systems, a great deal more must be learned about the problems involved. Currently, they are little more than speculation. Speculation, however, is the beginning of theory, and theory is the beginning of achievement.

Twenty-five years from today, a new generation of engineers may consider these ideas of ours as nothing more than the preposterous arrogance of ignorant men. On the other hand, perhaps they will look about themselves, be courteous and condemn us only for our conservatism.

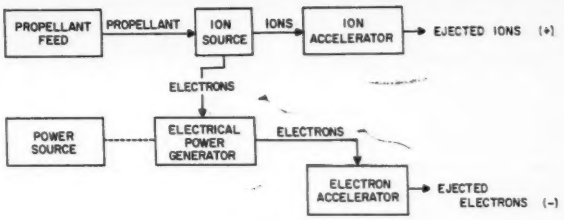



FIG. 11. Ion-propulsion system schematic.

### REFERENCES


[1] Tormey, J. T., *Liquid Rocket Propellants—Is There an Energy Limit?*, Industrial and Engineering Chemistry, Vol. 49, pp. 1339–1343, September, 1957.

[2] Malina, F. J., and Summerfield, J., *The Problem of Escape from the Earth by Rocket*, Journal of Aeronautical Sciences, Vol. 14, No. 8, pp. 471–480, August, 1947.

[3] Glasstone, S., and Edlund, M. C., *The Elements of Nuclear Reactor Theory*, D. Van Nostrand Co., Inc., N.Y., 1952.

[4] Clarke, A. C., *Interplanetary Flight*, Harper Brothers, N.Y., 1952.

[5] Shepherd, L. R., and Cleaver, A. V., *The Atomic Rocket*, J. Brit. Interplanetary Soc., Vol. 7, pp. 184, 234, 1948. Volume 8, pp. 23, 59, 1949.

[6] Shepherd, L. R., *Interstellar Flight*, J. Brit. Interplanetary Soc., Vol. 11, pp. 4, 150–167, July, 1952.

[7] Seifert, H. S., *A Rocket Engineer Looks at Atomic Energy*, California Institute of Technology Publication, p. 4, May 15, 1946.

[8] Rosenblum, M., Reinhart, W., and Thompson, T., *Rocket Propulsion with Nuclear Energy*, American Rocket Society 12th Annual Meeting, N.Y., December, 1957.

[9] Bergaust, E., *Russian Atomic Rocket Underway*, Missiles and Rockets, Vol. 1, pp. 30–32, October, 1956.

[10] Glasstone, S., *Principles of Nuclear Engineering*, D. Van Nostrand Co., Inc., N.Y., 1955.

[11] Stephenson, R., *Introduction to Nuclear Engineering*, McGraw-Hill Book Co., Inc., N.Y., 1954.

[12] Cleaver, A. V., *Rocket Propulsion*, Forecast, Vol. 10, pp. 5, 11, 19, 24, December, 1948.

[13] Seifert, H. S., *Is the Nuclear-Powered Rocket Feasible?*, Physics Today, pp. 6–13, May 2, 1949.

[14] Serber, R., *The Use of Atomic Power for Rockets*, RAD-2, Douglas Aircraft Co., July 5, 1946.

[15] Dillaway, R. B., *Typical Propulsion Systems for Space Flight*, Space Propulsion Session, IAS 26th Annual Meeting, N.Y., Jan. 27–30, 1958.

[16] Boden, R. H., *The Ion Rocket Engine*, Rocketdyne Report R-645, Canoga Park, Calif., August 26, 1957.

[17] Clauser, M. U., *Magnetohydrodynamics*, Lecture 17B of Space Technology Course, University of California Engineering Extension, Physical Science Extension, May 12, 1958.

[18] Tsien, H. S., *Thermonuclear Power Plants*, Jet Propulsion, Vol. 26, 1956.

[19] Bello, F. C., *Fusion Power: The Trail Gets Hotter*, Fortune, Vol. 56, No. 1, p. 135, July, 1957.

[20] Post, R. F., *Controlled Fusion Research—An Application of the Physics of High Temperature Plasmas*, Rev. Modern Physics, Vol. 28, p. 338, 1956.

[21] Giannini, G. M., *The Plasma Jet*, Scientific American, Vol. 197, No. 2, pp. 80–88, October, 1957.

[22] Colgate, S. A., and Aamodt, R. L., *Plasma Reactor Promises Direct Electric Power*, Nucleonics, Vol. 15, No. 8, August, 1957.



## New Publication Now Available

The Proceedings of the National Specialists Meeting on Dynamics and Aeroelasticity (November 6, 7, 1958) contains all **unclassified** papers presented at the meeting.

**Member Price: $3.50** **Nonmember Price: $6.00**

**Special Publications Dept., Institute of the Aeronautical Sciences, Inc., 2 East 64th St., New York 21, N.Y.**

*A description of how high bending stresses can be reduced by thin doublers of titanium or stainless steel engaging an extra row of rivets outside the main splice. While this introduces a problem in bimetallic corrosion, the gains in fatigue life and fail-safe features more than offset the extra work required for corrosion prevention.*

# Thin Doublers
## for Fatigue-Resistant Aluminum-Alloy Structures

C. R. Smith
Convair
A Division of General Dynamics Corporation

NOTWITHSTANDING the efforts toward designing airplane structures free of fatigue problems, we have to admit that it is difficult to build an airplane that will not suffer fatigue damage unless some sacrifice in weight is made. The alternative is to build airplanes in such a manner that certain amounts of fatigue cracking can occur without endangering the airplane safety. This is called fail-safe design.

One of the features of fail-safe design is that failures can take place in any one of a number of load-carrying members without such a loss of strength that the airplane would be endangered. Most redundant structures would fall in this category.

Some of the most critical locations in an airplane are in the doublers joining two sections of a fuselage. Here, the acoustical insulation and upholstery prevent ready inspection of the underlying structure so that fatigue cracking could conceivably progress to a danger point without being detected.

The solution to such a problem is either to make these structures so strong that they cannot fail in fatigue or to supply multiple paths of loading so that complete failure could occur along one path without losing an airplane. The fail-safe load as defined here (and which is generally recognized throughout the airplane industry) is 53 per cent of the design ultimate load.

At last year's meeting of the IAS (see footnote below), the author showed that the fatigue strength of a typical riveted joint could be increased over 20 per

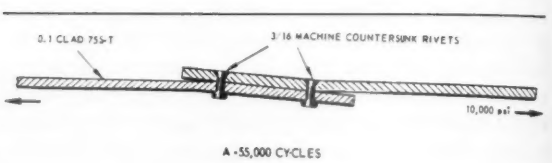


FIG. 1. (* Patent pending.)

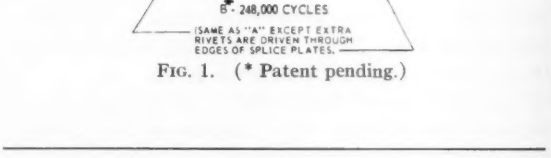



FIGURE 2A

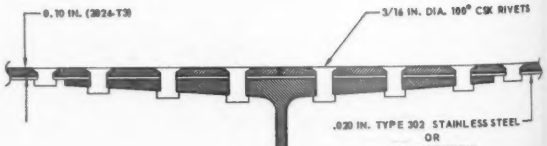



FIGURE 2B

---

This article is condensed from the author's paper, of the same title, presented before the Structures Session, IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959. It develops further the work described in "Aircraft Fatigue—Is Low-Strength Alloy the Answer?" a paper presented by the author before the IAS 26th Annual Meeting, 1958, in which test data were given showing that bending stresses at the first rivet or row of rivets contributed roughly one half of the total stress causing fatigue cracking. (The complete paper is available as IAS Report No. 59-21.)

The author is Design Specialist, San Diego.

cent simply by driving rivets through the edges of the splice doublers as shown in Fig. 1. Corresponding improvements in life amounted to between five and ten times. The purpose of the edge-driven rivets was to relieve the loaded rivet from bending stresses. Previous strain-gage measurements had shown that bending constituted about one half of the total stress at this location.

A corollary to this would be to allow bending to take place at the first rivet—but to reduce the total stress before it got to this first rivet by means of a thin doubler extending beyond the splice so as to pick up an extra rivet or row of rivets through the doubler and skin only. The doubler would have to be thin enough to minimize bending stresses at the auxiliary rivets and yet strong enough to reduce the loads going into the main splice. Furthermore, this type of structure would lend itself to fail-safe design, provided the strength of the doubler alone were sufficient to carry the fail-safe load.

## Test Program

### *Fatigue Tests*

Butt joints of 2024-T3 aluminum alloy 0.10 in. thick by 1 in. wide were prepared as shown in Fig. 2A, using 2024-T3 extrusion T-section as a splice plate. They were riveted with three 3/16-in.-diameter 100° countersunk 2024-T4 rivets on each side of the splice 1 in. apart. These were the control specimens and represented typical airplane structure.

Two additional sets of specimens were modified by inserting a doubler 0.020 in. thick of either 1/2 hard-type 302 stainless steel or of 6Al-4V titanium in the faying surfaces; this doubler extended beyond the extrusion to permit using an extra rivet through the doubler and skin only. These specimens are shown in Fig. 2B.

The stainless-steel doublers were cadmium plated prior to assembly. The titanium had a special corrosion treatment as follows:

(1) Hand wipe with methyl ethyl ketone.

(2) Vapor decrease in stabilized trichloroethylene.

(3) Clean 10 min. at 160°F. in a solution composed of 20 parts of $H_2SO_4$, 20 parts $H_2O$, and 4 parts $Na_2Cr_2O_7\,0.2H_2O$ (by weight).

(4) Rinse in tap, then in distilled water at room temperature.

(5) Dry 14 min. at 150°F.

(6) Spray with EC 1290 (Minnesota Mining Co.), dry 30 min. at room temperature, and cure 30 min. at 225°F.

All specimens were loaded axially in a Sonntag SF-1U fatigue-testing machine, using a stress ratio of 0.10 for all tests. Lateral support was provided at the middle of the T to prevent excessive vibration. Approximately four specimens at each stress level were used to determine log mean values from which *S-N* curves were plotted.

A duplicate number of specimens were also prepared as above and exposed to the Federal Test Method Standard 151, Method 811, Salt Spray test (250 hours of 20 per cent solution NaCl spray at 95°F.). The edges of these specimens were protected by paraffin.

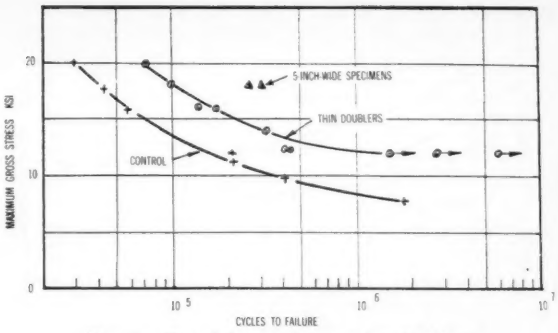



FIG. 3. Butt joints with extrusion doublers.

Two large 5-in.-wide specimens of each type—with the exception of substituting 0.020 2024-T3 for titanium doublers—were also tested. These, however, were loaded at nominal gross stresses of 10,500 psi nominal gross stress with a stress ratio of 0.16.

The extrusions in two of the 5-in.-wide specimens and four of the small specimens were sawed in two along the innermost line of rivets, leaving only the steel or titanium doublers holding. These were cycled at 10,000 psi nominal gross stress.

A third type of specimen, not representative of a fail-safe structure, was prepared in the form of butt joints $1^1/_4$ in. wide by 0.064 in. thick 7075-T6 alloy with an 0.020-in. stainless-steel doubler. The purpose of these was to determine whether steel doublers alone would suffice for use where fail-safe features were not required but where the use of thin doublers would avert the need for joggling. Three 3/16-in.-diameter 100° countersunk rivets were used on each side of the splice, the countersunk being on the 7075-T6 side.

A second group of the same type was modified by driving rivets through the edges of the doublers in such a manner that the center of the rivet fell directly in line with the edge of the doubler. This was the same procedure used for the edge-driven rivet described in the paper presented at last year's meeting.

### *Static Tests*

In order to obtain allowable data for static design on stainless-steel doublers, lap joints of 0.064-in. aluminum to 0.020-in. stainless steel were prepared. Two rivets 1 in. apart were used. These were tested in a Baldwin 120,000-lb. hydraulic testing machine, using a dial indicator extensometer for measuring deformation and set across the joint. The yield strength for the purpose of this program was defined as 0.005-in. permanent set across the joint, conforming with standards set for ANC-5.

## Test Results

### *Fatigue*

The results of fatigue tests on 1-in.-wide butt joints with extrusion splice plates are presented in Fig. 3.

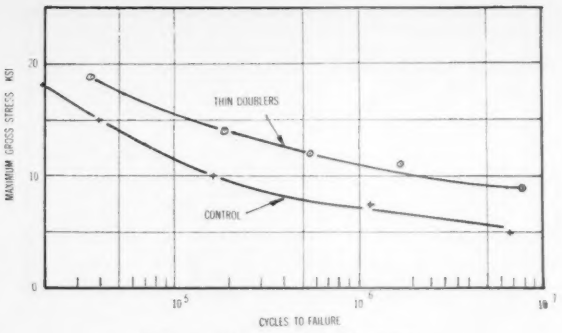



FIG. 4. $1^1/_4$-in-wide butt joints.

The points plotted represent the log mean life of a number of specimens, except where runouts (as indicated by arrows) were present. The ordinates are for nominal gross stress in the aluminum sheet away from the splice area.

The graph for the specimens with thin doublers include both stainless steel and titanium, with no apparent difference in fatigue lives between the two. In a number of cases, failures occurred through the combined extrusion and steel doubler. These data are not included in the log mean lives but are plotted as separate points. This particular thickness combination of extrusion and skin does not reflect that used in design. Rather, it was arbitrarily chosen in order to induce failures in the doubler region so that time elapse between extrusion and doubler failure could be observed.

Unfortunately, when doubler failures occurred at high stress level loading, final failure was observed almost immediately afterward; failures for low stress level (long running specimens) were not observed because they usually took place after the technician was off duty. (The laboratory procedure is to set up low stress level specimens for overnight running.)

At the time of this writing all the salt spray fatigue data were not complete. However, those available do not indicate a change in life for either the controls or those specimens with auxiliary doublers.

The controls for the 5-in.-wide specimens, which were run at 10,500 psi nominal gross stress with $R$ = 0.16, failed after 676,000 and 717,000 cycles, respectively. Two specimens with steel auxiliary doublers did not break after ten million cycles of the same loading. The test was stopped at this point and the load raised to 18,000 psi, whereupon failure occurred after 269,000 and 301,000 additional cycles, respectively. These are the two triangle points plotted in Fig. 3.

Two 5-in.-wide specimens with 0.020 aluminum-alloy doublers failed after 3,674,000 and 4,220,000 cycles of 10,500 psi repeated loading, $R$ = 0.16.

The 5-in.-wide specimen with sawed extrusion (steel auxiliary doubler only holding) failed after 20,000 cycles of 10,500 psi nominal gross stress repeated loading, $R$ = 0.16.

Two 1-in.-wide specimens with sawed extrusions failed after 182,000 and 106,000 cycles of 10,000 psi nominal gross stress repeated loading, respectively.

Fatigue test results for the $1^1/_4$-in.-wide butt joints with steel doublers are given in Fig. 4. The lower graph represents a conventional splice with equal thickness aluminum doubler. The upper graph is for the 0.020 steel doubler with edge-driven rivets. All failures occurred through the first rivet in the controls. However, where edge rivets were used in steel doublers, the failures for high level loading occurred through the edge rivet, while, for lower level loading, cracks were noted at many locations—in one case, at five of the eight rivets used in the joint (four on each side of the splice, including the edge rivet). In some cases, final failure took place through one of the middle rivets.

### *Static*

Two each of the shear test specimens gave the strengths per rivet given in Table 1.

## DISCUSSION

In addition to improved fatigue life, the thin, high-strength doubler, being a second doubler, improves the fail-safe performance of the splice. Generally, such splices occur in areas employing plate-stringer combinations. Although plate-stringer structures are inherently fail-safe to some degree, the design should ensure that, if fatigue failure occurs, it would be in the skin where the failure is visible from the outside of the structure.

In the above program, a number of the failures were through the extrusion, or what would be a hidden area. This would indicate that some other ratio of doubler to skin and extrusion thickness would be in order; however, more work would be required to establish this optimum ratio.

This program, which was limited to only one thickness of doubler, showed rather substantial gains in fatigue strength. Undoubtedly, still greater gains could be had by establishing optimum skin to doubler thickness ratios.

## CONCLUSIONS

From the above program, it appears that added fatigue strength or weight-saving can be achieved by using thin auxiliary doublers of high-strength material in an aluminum-alloy structure.

While the improvements shown here are substantial, they are by no means optimum. An extrapolation into

(*Continued on page 49*)

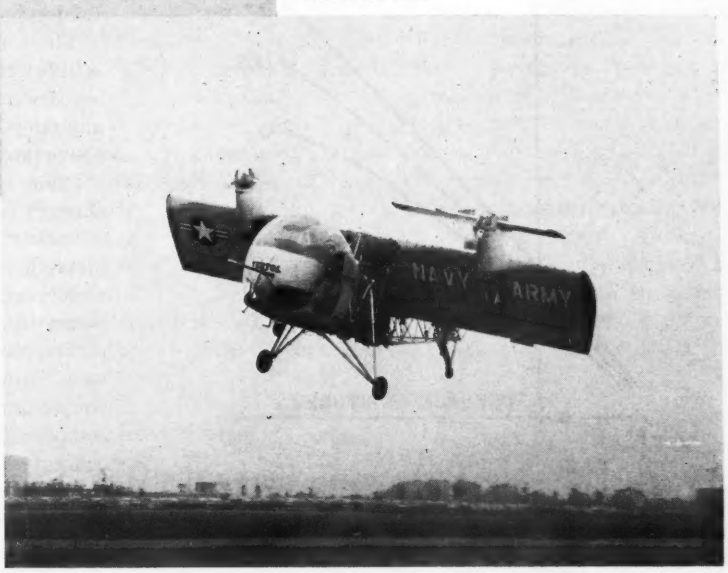
TABLE 1

| | Yield, Lbs. | Adjusted Yield,* Lbs. | Ultimate, Lbs. |
|---|---|---|---|
| Control | 1,360 | | 2,330 |
| | 1,410 | | 2,280 |
| Steel | 1,120 | 890 | 1,325 |
| Doubler | 1,150 | 850 | 1,280 |

* Adjusted to 66.7 per cent of the ultimate failing load. This was not necessary for the control because the 0.005-in. slip load was less than this value.

W. Z. Stepniewski
and
Paul J. Dancik
Vertol Aircraft Corporation

Fig. 1. Vertol-76 in STOL configuration—a turn with the wing in an intermediate position. (Note tufts in left turn.)




# Flight Testing Experiments with the TILT-WING AIRCRAFT

*Actual experience confirms that small flight research aircraft are a logical means of proving—quickly and at a reasonable cost—the basic feasibility of a new concept.*

THE VERTOL-76 (Fig. 1) is one of the several flight research aircraft, sponsored by the U.S. Army and coordinated by the Office of Naval Research, which have been developed to investigate technical feasibility of the most promising VTOL systems.

On July 15, 1958, L. J. LaVassar, Chief Test Pilot, took the Vertol-76 for the first time through a complete conversion from hovering to forward flight and back to hovering. By the end of October, 1958, a total of 17 complete conversions, as well as numerous partial conversions from STOL to hover, or from hover to STOL configurations, were performed. It is believed that, with these conversions, the main goal of the design and construction has been accomplished. But, in addition to fulfilling the main purpose of its existence, the aircraft proved itself a useful research tool. The present paper is written in order to present, without delay, the important topics of our experience, even if some results may still remain of a preliminary or a qualitative nature only.

Since the aircraft itself, as well as its design philosophy, stress criteria, etc., have been previously described (references 1–3), only a brief description and its most important characteristics are given.

## Description of Aircraft and Test Program

The Vertol-76 is a versatile VTOL-STOL aircraft possessing rotary wing and fixed wing capabilities.

**Mr. Stepniewski is Assistant Vice-President of Engineering for Research. Mr. Dancik is Project Engineer.**

**This article is a condensed version of a paper by the same title presented before the VTOL Design Session, IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959. (The complete paper is available as IAS Report No. 59-8.)**

**The authors wish to express their indebtedness to L. L. Douglas, Vertol's Vice-President of Engineering, for his valuable technical contributions to the program discussed.**

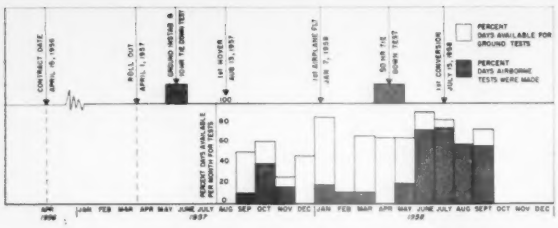

CONTRACT DATE
APRIL 15, 1956
ROLL OUT
APRIL 1, 1957
GROUND HOVER & COMPLETE TIE DOWN TEST
1st HOVER
AUG 13, 1957
1st AIRPLANE FLT
JAN 7, 1958
50 HR TIE DOWN TEST
1st CONVERSION
JULY 3, 1958
PERCENT DAYS AVAILABLE FOR GROUND TESTS
PERCENT DAYS AIRBORNE TESTS WERE MADE
PERCENT DAYS AVAILABLE FOR AIRBORNE TESTS
APR 1956
JAN FEB MAR APR MAY JUNE JULY AUG SEP OCT NOV DEC
1957
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1958

FIG. 2. Summary of the Vertol-76 development.

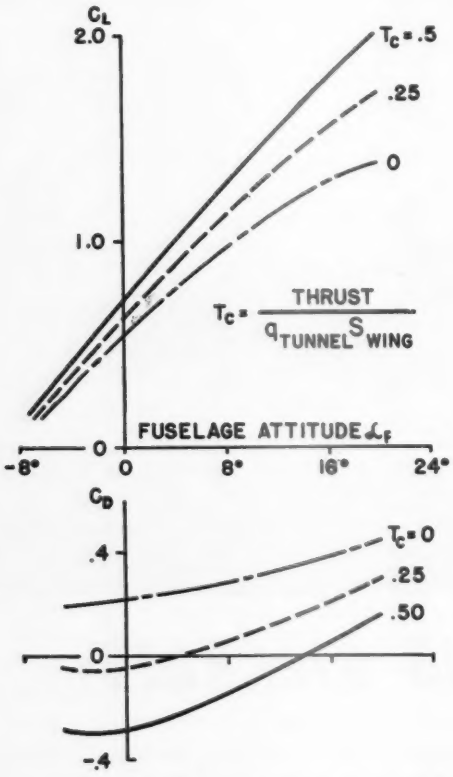



FIG. 3. Influence of propeller thrust coefficient ($T_c$) on lift and drag coefficients of the 1/4 scale model (example of NASA wind tunnel force tests).

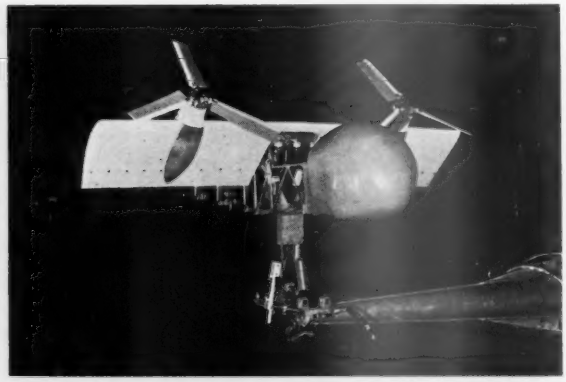


FIG. 4. Dynamic model of the "76" on the Princeton University test track.

The aircraft is powered by a Lycoming T-53 free gas turbine (limited to 600 s.hp.) which provides power to the two main rotors and to two tail fans. The two main rotors are used for vertical lift and roll control in hover and forward propulsion in airplane flight. The two tail fans provide control in hover and supplement the tail control surfaces in forward flight as the tail fans and tail control surfaces operate simultaneously through all regimes of flight.

The cockpit controls are conventional, consisting of longitudinal and lateral control stick, rudder pedals, and collective pitch lever. An electrical up-down switch is provided on top of the pilot's control stick which is used to position the wing at any attitude.

The conversion from helicopter to airplane controls is fully automatic and accomplished through mechanical actuation by the wing tilt. The pilot need not adjust any additional controls other than tilt the wing, which he operates with his thumb.

Prior to full conversion flights, the "76" went through an extensive ground and flight test program, including functional checkout of equipment, a ground instability test, and a preliminary 10 hour tie-down endurance test. Airborne flights (hovering) commenced on August 13, 1957, and taxi tests, which started earlier, continued. During this phase modifications were made to improve hover and taxi characteristics. On January 7, 1958, the first airplane flights were accomplished, indicating good controllability and stability characteristics.

Upon the completion of hover, taxi, and airplane flights, the aircraft was put through an additional 50 hour tie-down endurance test. This test was accomplished in nine days, with the aircraft in operation as much as 13 out of the 16 scheduled work hours. Then the entire dynamic system, as well as the control system and critical fuselage joints, landing gear, and tail fittings, were disassembled and inspected.

After the installation of a complete new dynamic system, the first in-flight wing tilts were made on June 6, 1958. These maneuvers were followed by STOL take-offs, stabilized flight, and landing with the wing fixed at intermediate positions. Once the STOL characteristics of the aircraft proved satisfactory, a successful conversion flight was performed.

History of the development of the aircraft is summarized in Fig. 2, while Table 1 gives its most important characteristics.

TABLE 1
Dimensional and Weight Data

| | |
|---|---|
| Gross weight | 3,300 lbs. |
| Weight empty | 2,500 lbs. |
| Wing span | 24 ft. 11 in. |
| Length | 26 ft. 5 in. |
| Height | 10 ft. |
| Rotor diameter | 9 ft. 6 in. |
| Tail fan diameter | 2 ft. |
| Wing area | 110 sq. ft. |
| Wing airfoil | 4415 |
| Disc loading | 23.5 psf |
| Wing loading | 30 psf |
| Engine | Lycoming YT-53 derated to 600 s.h.p. |

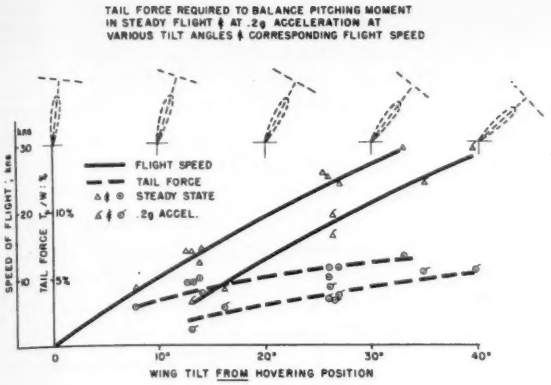

TAIL FORCE REQUIRED TO BALANCE PITCHING MOMENT
IN STEADY FLIGHT & AT .2g ACCELERATION AT
VARIOUS TILT ANGLES & CORRESPONDING FLIGHT SPEED
FLIGHT SPEED
TAIL FORCE
STEADY STATE
.2g ACCEL.
SPEED OF FLIGHT, kns
TAIL FORCE T, / W, %
WING TILT FROM HOVERING POSITION

FIG. 5.

## SUPPORTING RESEARCH

Preliminary design of the aircraft was greatly helped by NASA published reports and direct contacts with the personnel of the Free Flight and Stability Sections of NASA. A quarter scale aerodynamic model was built for force and free flight tests at NASA and the results are being prepared for publication by the NASA. Fig. 3, showing the influence of the propeller thrust coefficient ($T_c$) on lift and drag coefficient of the wing, is given here as an example.

Flow phenomena associated with the propeller wing combination were studied through flow visualization in the smoke wind tunnel at the Forrestal Research Center of Princeton University. These results spectacularly indicated the influence of the propeller slipstream in reduction of the actual wing angle of attack, with respect to the resultant slipstream (see reference 2, p. 316). They also indicated that, due to the rotation of the slipstream, the degree of stall alleviation is slightly different on both sides of the propeller axis. Fig. 1 seems to confirm those findings as tufts behave differently to the left and to the right of the nacelle.

In order to get a better insight into control, stability, and general aerodynamic phenomena of conversions, a dynamically similar 1/4 scale model of the aircraft was constructed by the Forrestal Research Center with the intent to test it on their track (Fig. 4) under simulated free-flight conditions. From this test, aerodynamic characteristics and stability derivates could be obtained. The present program consists of a three component testing of the model in the tail-off configuration.

Lift of the propeller wing assembly is so adjusted that at a given fixed wing tilt it balances the gross weight. Then drag and pitching moments are measured at a constant velocity and variable angle of attack of the fuselage. These measurements are repeated at a constant fuselage angle and varying "flight" velocities. From this information, a relationship between wing tilt angle and tail force, required to balance pitching moment, as well as flight speed corresponding to the steady state, accelerated or decelerated flight conditions, can be obtained.

Fig. 5 is given as an example of the information which can be obtained from these tests. Although present results are of a preliminary nature, and hence it would be premature to define their degree of accuracy, at least some qualitative agreement between them and actual flight tests may be claimed. A comparison with Fig. 10 will indicate that in actual flight speeds of flight in steady-state conditions are close to those given by Fig. 5, and the direction of balancing force, as indicated by the stick displacement in actual conversions, is in agreement with the model results.

An actual Vertol-76 propeller was tested through 180° from hovering to vertical descent at the NASA Ames Full-Scale Wind Tunnel. Tests were conducted at 800, 1,000, and 1,100 r.p.m. instead of the 1,400 required in actual flight. The results, although not completely conclusive due to the above deviation in r.p.m., did not reveal any unusual behavior of the propeller in all regimes of flight, with the exception of vertical descent when, even at the very low rates (4 to 20 ft. per sec.), an excessive, somewhat irregular, blade flapping was observed. To what extent this may be resulting from the wind-tunnel wall interference is not known at present. This phenomenon will probably be investigated further, and additional tests of the propeller will be run at the Ames tunnel at full r.p.m.

## CONTROLLABILITY

During design of the "76," the only guidance regarding control response requirements in hovering could be obtained from helicopter experience and an attempt was made to match those standards (Table 2).

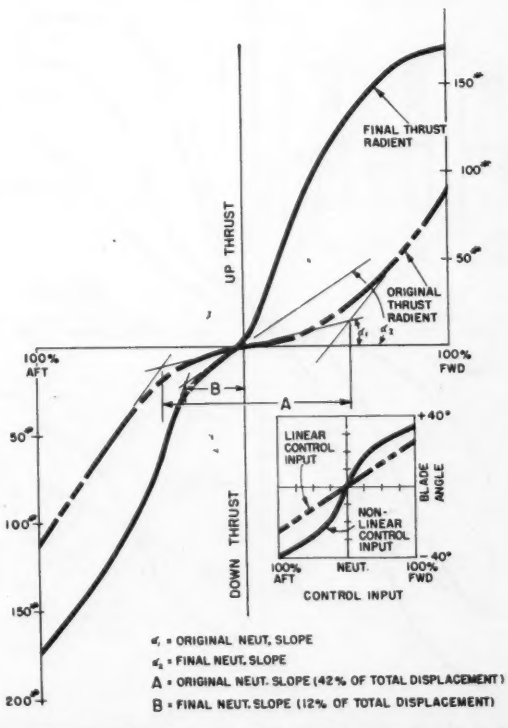



FIG. 6. Thrust vs. control displacement for pitch fan.

TABLE 2
Initial Acceleration per in. of Control Displacement deg. sec.²/in.

| Axis | Helicopters | Vertol-76 Design | Vertol-76 Estimated from Tail Force Measurements |
|---|---|---|---|
| Pitch | 8 | 8 | 7.9 |
| Roll | 25–40 | 25 | ... |
| Yaw | 6–20 | 7 | 5.2 |

Flight experience seems to indicate that response in roll is completely satisfactory, pitch adequate, but more would be desirable, while yaw still remains rather marginal at high wing incidences. The first hovering flight clearly showed that more pitch and yaw control was required and then a corrective action was taken. The pitch control response was brought to its present limit by increasing the total thrust and improving the response gradient in the neutral stick area (Fig. 6, and references 1 and 3). The yaw control was modified similarly and hovering became possible. However, it was later found that at approximately 10°–20° wing tilt from its hovering position, directional control became marginal. Analysis of the yaw fan installation disclosed that the fuselage tubes, lubrication lines, and the transmission case created considerable drag, making it only 40 per cent as efficient as the pitch fan.

In order to improve its effectiveness, the yaw fan was moved outboard by additional 4 in. and an annular ring of the cross section shown in Fig. 7 replaced the round safety guard.

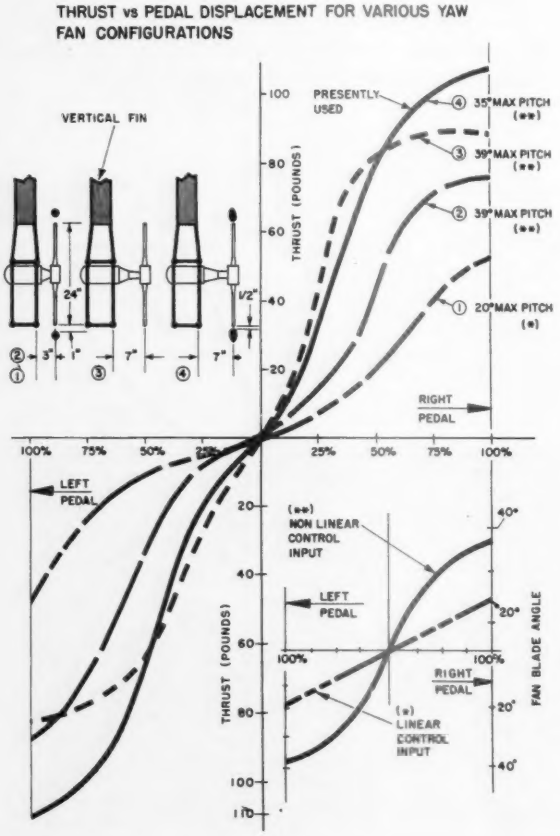


FIG. 7.

Relocation of the yaw fan outboard improved right rudder thrust (which was worse) by approximately 37 per cent at maximum control displacement, while the annular ring increased it by 16 per cent. Cleanup of the yaw fan area resulted in a 10 per cent increase in thrust. These changes improved the yaw fan thrust by 63 per cent over the original installation, making it 60 per cent as efficient as the pitch fan. Directional heading could now be maintained at all wing positions; however, at wing incidence angles of 65°–75° more pedal displacement is used than desired.

Control effectiveness in pitch and yaw improves rapidly with forward speed, as action of the control fans is supplemented by aerodynamic surfaces. No difficulties about those axes were expected, hence, in conversion or in steady-state flights at a fixed wing tilt angle. The problem of roll in the above flight conditions required more attention. Since it had been decided that the aircraft should be flown in steady-state flights at any fixed wing position between hovering and airplane incidences, it was necessary to provide an adequate roll control even if large asymetric moments about the longitudinal axis would develop. With a proper scheduling of ailerons and differential collective pitch at all wing tilt angles, enough rolling moment was provided to deal even with the case of a complete stall of one-half of the wing while the other experiences its maximum lift coefficient.

Instrumented tests and pilot evaluation indicate that ample control is available, and that lateral stick trim positions are not excessive in any flight regime. Maintaining altitude under all flight conditions, even close to the ground (10–15 ft.), does not present any problem.

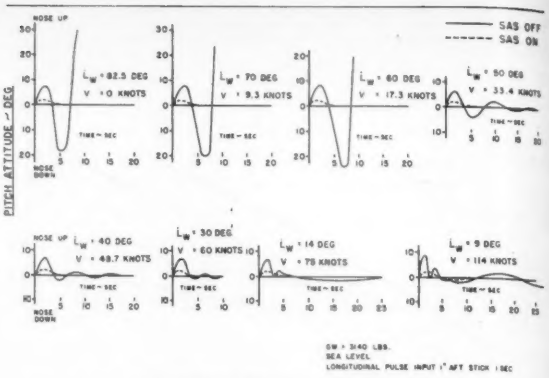


FIG. 8. Analog studies of longitudinal dynamic stability in hovering and conversion with and without the Stability Augmentation System.

## STABILITY

Dynamic stability studies conducted on an analog are summarized in Fig. 8. They indicate that in hovering ($i_w$ = 82.5°) and down to the wing incidence of about 60° the aircraft is divergent in pitch motion.

However, at lower wing incidences (see $i_w = 50°$ and lower in Fig. 8) the aircraft becomes dynamically stable.

Fig. 8 also indicates (see broken lines) that with a Stability Augmentation System, consisting of a pitch rate damper with a 0.10 sec. lag, stability can be obtained in hovering and at high wing incidences. Similar improvements may be expected for the roll axis.

Although hovering flights (12 min. in gusty air) were performed without any stability aids, the SAS developed for Vertol's tandem helicopters (see reference 4 and Fig. 9) was adopted for the pitch and roll axes.

Pilot's opinion seems to confirm the analog findings regarding the ease of controlling the aircraft in hovering and at high wing incidences with the SAS. In this case, controls in hovering may be held fixed for over 10 sec.

SAS was installed to assist the pilot through transition, but later tests showed that those devices are not needed in all regimes of flight. Referring to the longitudinal stick position curve (shown in Fig. 10), the solid line gives a steady trim change through conversion. The broken lines represent the extremes of control motions used with the pitch rate damper turned off. It is interesting to note that the pitch rate system is helpful in providing stability augmentation during the hover, and for approximately 25 per cent of the initial wing tilt. As the wing is tilted further, longitudinal stability increases rapidly, and during the remainder of the conversion cycle the pilot notices a negligible difference in the longitudinal stability characteristics between manual control and stability augmented control.

## Vibration

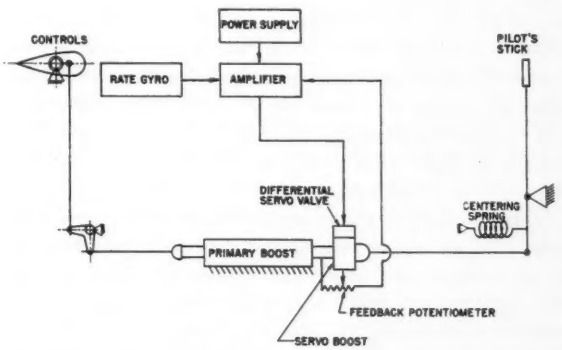
Vibration level of the Vertol-76 in hovering, conversion, and forward flight compares favorably with that of light planes in the same weight class.

The lack of any noticeable low-frequency vibrations (buffeting) in conversion and at high incidences can be attributed chiefly to the slipstream effect maintaining the wing below the stall. However, theoretical studies, as well as tuft examination, seem to indicate that wing stall angle may be exceeded in some flight conditions, and the flow separates over some portions of the wing. The fact that even in this latter case buffeting can hardly be noticed can be attributed to the favorable characteristics of the NACA-4415 airfoil section.

Absence of the higher frequency vibrations, induced by the propellers, may be credited to a careful analysis of the problem[5] and an incorporation of structural changes required for favorable dynamic characteristics of the wing-propeller combination.

The general approach to the propeller induced vibration problems may be outlined briefly as follows:

The Vertol-76 propeller blades are equipped with flapping hinges which contribute to the attenuation of higher harmonic forces parallel to the shaft. In order to deal in the same manner with higher harmonic forces in the plane of the propeller disc, incorporation of lag hinges would be required. But the presence of these lag hinges in combination with the many wing elastic motions almost certainly would lead to some form of mechanical instability. Prevention of this instability, either through a very high natural frequency of the wing (extreme rigidity), or by introduction of a complicated system for damping of the wing elastic motions, would require a high penalty in weight and cost. The problem was solved hence by taking an advantage of the wing flexibility in the normal to the chord direction, accompanied by considerable damping, which provided some attenuation of propeller induced forces in the plane perpendicular to the span. Although components of the propeller induced forces parallel to the span cannot be attenuated by the wing deflections because of its high rigidity, nevertheless, they probably cancel within the wing propeller system because of the opposite propeller rotations and proper blade phasing. It should be noticed from Table 3 (reproduced from reference 5) that natural frequencies of the wing in both helicopter and airplane configuration are rather well removed from the second and third propeller harmonics. But some of the wing natural frequencies are close to the first rotor frequency. Indeed, whenever some unbalance in the propeller blade




SCHEME OF STABILITY AUGMENTATION SYSTEM USED IN PITCH AND ROLL

Fig. 9.

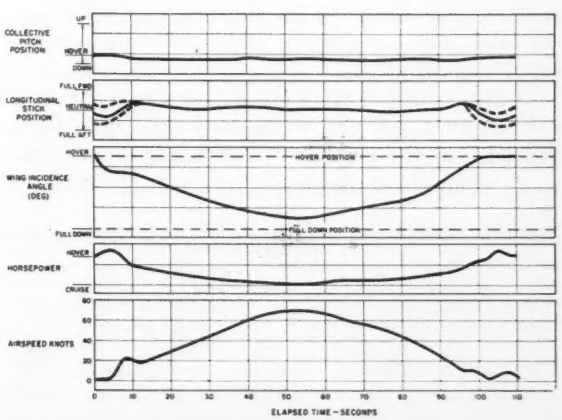



Fig. 10. Typical time history of conversion. Solid and broken lines show longitudinal stick displacements with and without the SAS.

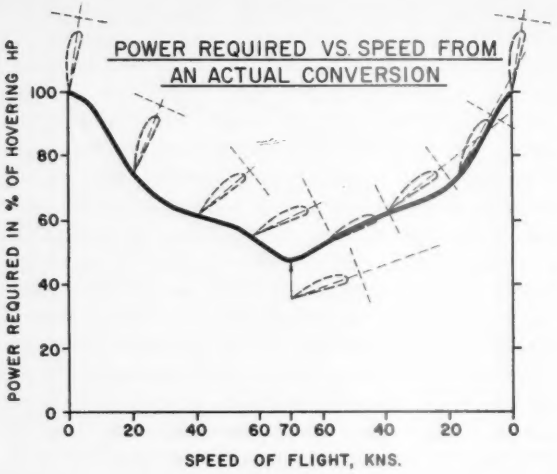



FIG. 11.

was present (one per rev. excitement), the unusual vibrations in the aircraft were quite noticeable.

## CONVERSION AND STOL

Control, stability, and other aspects of the conversion and steady-state flights with intermediate wing position have already been discussed. But the power required was not considered as yet. It can be seen from Fig. 10, or better from Fig. 11, that during conversion power decreases rapidly in spite of the fact that some part of it may be used for the acceleration. At a wing incidence of about 65° and a corresponding speed of flight of about 25 knots, the power required amounts to less than 70 per cent of that in hovering. This rapid drop in power, combined with the previously discussed good control characteristics, makes the tilt wing configuration especially suitable for STOL operations at gross weights higher than those which can be achieved in hovering. Fig. 12, based on theoretical calculations, clearly indicates that for a 600 ft. take-off distance over 50 ft. obstacle the gross weight can be increased by about 13 per cent over the hovering weight which, obviously, represents a very considerable gain in the payload. Fig. 12 also indicates that STOL performance may be improved still further through the use of simple flaps.

At the moment of this writing there are no quantitative results to support or disprove those theoretical findings, but the necessary data should be available shortly from instrumented STOL tests. At present it may be only stated that, according to the pilot's observations, when the wing is at an incidence of about 65° and lower, take-offs with very short ground runs (less than one length of the aircraft) are performed with power setting lower than in hovering.

TABLE 3
Wing Natural Frequencies in Hovering and Airplane Flight Configuration

| Wing Position | Antisymmetric: Chordwise | Antisymmetric: Coupled Beamwise Bending-Torsion | | |
|---|---|---|---|---|
| | 1st | 1st | 2nd | 3rd |
| Up | 1.829 | 0.445 | 0.94 | 2.58 |
| Down | 1.188 | 0.632 | 1.02 | 2.66 |
| | Symmetric | | | |
| Up | 1.08 | 0.448 | 0.949 | 2.59 |
| Down | 0.866 | 0.441 | 0.949 | 2.59 |

## AVAILABILITY AND MAINTENANCE

After qualification of the aircraft by a 50 hour tie-down endurance test, an aircraft availability as high as 91 per cent was achieved; with days airborne per month as high as 81 per cent. The average availability rate since the tie-down was 70 per cent (see Fig. 2). This average falls within the availability range of military fixed wing aircraft and well above military rotary wing aircraft.

It may be argued that the Vertol-76 aircraft is a research aircraft which may have received special maintenance attention during its test phase which standard operational aircraft may not get and which may also be down due to lack of spares. However, the above statistics are presented here only to obtain a feeling for the availability rate. They seem to indicate that the tilt wing configuration which has the capability of rotary wing and conventional aircraft, need not possess compound maintenance problems but ranks with operational aircraft.

## CONCLUSIONS

As indicated in reference 6, and confirmed by actual experience, small size flight research aircraft (test

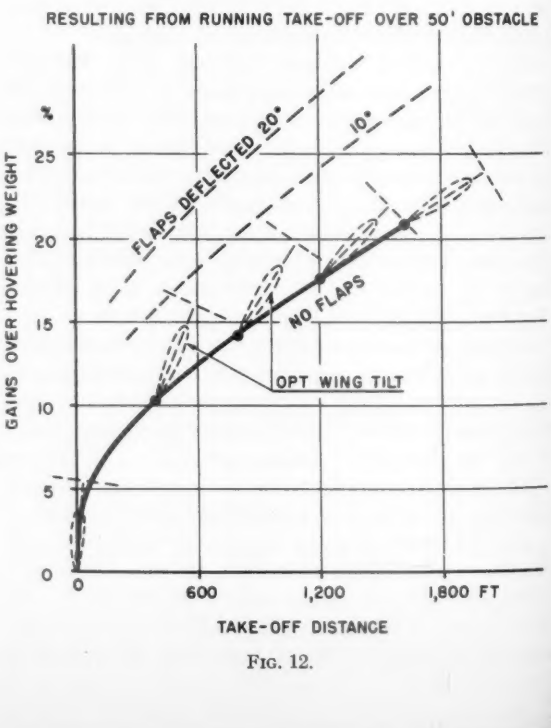



FIG. 12.

beds) represent a logical way of proving, within a short time and at a low cost, the basic feasibility of a new concept. Furthermore, they become a useful tool of design[7] and flight research. It is obvious that they should not be considered a substitute for the development of operational aircraft, or be used as an excuse for the delay of this development until every possible research program with the flying test beds is completed. On the contrary, they should be a means to accelerate the development of operational aircraft by providing technical information on which to base specification requirements, and serve as an insurance against time and money consuming technical errors in the basic concept and design. However, in order to achieve this double goal of test beds, the whole program should be so timed that the important results will be obtained promptly and as much as possible in advance of the construction of operational aircraft. Since flight research aircraft may be used to obtain information on various specific problems, the degree of aerodynamic or flying quality refinements of such aircraft should obviously be tailored to the problem for which the answer is required.

With respect to the tilt wing configuration, it is believed that the following areas may be further explored with small and inexpensive flight research aircraft with benefit not only to this particular system but to other VTOL's as well:

(a) Establishment of flying quality requirements. A flying test bed incorporating variable controls with a much higher ultimate capacity than the present Vertol-76 may be used for this purpose as a variable response aircraft. Incorporation of variable stability features would also be desirable, thus making it an ideal tool for flying qualities research. In order to formulate realistic requirements for flying qualities, the aircraft should be flown under actual atmospheric and terrain conditions, as no amount of analytical and analog studies, even supported by experience with helicopters and fixed wing aircraft, although very useful as a guide, can be substituted for this direct approach.

(b) In STOL problems flying test beds may prove themselves as a very useful flight research tool. As previously mentioned, theoretical calculations (see Fig. 12) indicate that incorporation of slotted flap would considerably improve STOL capability of the tilt wing. Actual flight programs may help to answer the question whether the additional complexity is justified by the improved performance.

(c) Some propeller problems, both aerodynamic and configurational, lend themselves to the test bed approach. Question of a compromise in propeller performance between hovering and forward flight can be investigated in this way. The same would be true of comparing known merits of flapping blades, such as possible contribution to damping and control through the offset hinges with greater simplicity of the rigid ones.

(d) Various concepts of a simplification of VTOL controls can be best investigated through flying test beds.

(e) In addition to the above-mentioned and similar technical problems, there are numerous operational aspects which can be properly evaluated only by flying these new machines by a number of pilots and under conditions as close as possible to the actual future operations. In this latter case, small inexpensive flight research aircraft may prove their usefulness as forerunners of the larger and more expensive operational machines.

### References


[1] Dancik, Paul J., Mazzitelli, Fredric, R., and Peck, William B., *Test Experience on the Vertol 76 Tilt-Wing VTOL Research Aircraft*, Proceedings of the 14th Annual National Helicopter Forum, Washington, D.C., 1958.

[2] Stepniewski, W. Z., *Tilt Wing Aircraft in Comparison with other VTOL and STOL Systems*, J. Helicopter Assn. Gt. Brit., December, 1957.

[3] Dancik, Paul J., and Peck, William B., *Design Aspects and Flight Testing of the Vertol 76, VTOL "Research Aircraft,"* Paper (58-A-278) presented at the A. S. M. E. Annual Meeting, December, 1958.

[4] Blake, Bruce, Clifford, James M., Kaczynski, Raymond, and Sheridan, Philip F., *Recent Advances in Flying Qualities of Tandem Helicopters*, Proceedings of the 14th Annual National Helicopter Forum, Washington., D.C., 1958.

[5] Loewy, R. G., and Yntema, R. T., *Some Aeroelastic Problems of Tilt Wing VTOL Aircraft*, AHS J., pp. 35–57, January, 1958.

[6] Stepniewski, W. Z., and Mallen, Joseph, *Evaluation of VTOL Systems Suitable for Transport Aircraft*, Aeronautical Engineering Review, Vol. 16, No. 9, pp. 60–68, September, 1957.

[7] O'Malley, James A., Jr., *The X-14 Airplane—a Design Tool*, Paper (95B) presented at SAE Aeronautical Meeting in Los Angeles, Calif., September-October, 1958.


✦ ✦ ✦

## Thin Doublers for Fatigue-Resistant Aluminum-Alloy Structures *(Continued from page 42)*

the future would indicate that eventually a state in the art of designing fatigue-resistant structures will be reached where fatigue will not be a problem. Certainly, there is little doubt that this would be true were a structure to be designed in such manner that its fatigue strength were equivalent to that of smooth polished specimens of the same material.

The effective concentration factor for these specimens was about 3. That for a rivet-filled hole has been shown to be between 1.2 and 1.5. Certainly, the next step toward designing fatigue-resistant structures would be to approximate the fatigue strength of rivet-filled holes; this could be done mechanically. Further improvement would probably depend on adhesive bonding, in addition to proper proportioning of doubler to skin thickness.

*"The operation of a large device is a test almost as much of care, thoroughness, and plain good luck as it is of basic design. Because tests in the development of a nuclear rocket motor are so expensive, and because of the essential one-shot nature of a power run on a given reactor, even more attention must be given to an appalling myriad of details than is the practice with chemical rocket motors."*

## Potentialities and Problems of

# Nuclear Rocket Propulsion

T. P. Cotter
University of California

NUCLEAR ROCKET propulsion today is at an awkward age. It has acquired a large literature of speculation and analysis. It has yet to exhibit a reactor producing useful thrust. We are now at the beginning of the long, arduous task of making real hardware actually work.

This is not to imply that the time for new ideas in this field is over. On the contrary, the obviously large gap which lies between the energy available in nuclear reactions and the modest use we can now venture to make of this energy for rocket propulsion, together with the richness of possibilities for closing this gap, provide ample stimulation to the search for better systems. But we have at hand a number of worthwhile concepts, and we begin, as we must, by putting these to the test of experiment.

The real problem of nuclear rocket propulsion is, bluntly, to demonstrate performance which is in some recognizable sense better than a competitive chemical rocket system. There are two generally agreed areas of potential nuclear rocket superiority. These are, first, delivery of large payloads from the ground, or near it, to ranges requiring high velocities; and, second, space flights with substantial payloads using small accelerations over comparatively long periods of time. The propulsion systems required for operation in the two areas are quite different. What may be accomplished in each is circumscribed primarily by the ways in which nuclear energy can be released with present knowledge and by the limitations of structural materials to withstand stresses at high temperatures.

### THE POTENTIALITIES

We may have fission energy either as the detonation of a bomb or as the controlled evolution of heat. The audacious notion of using the impulsive thrust of a series of small nuclear explosions to propel a sturdy structure into space was first proposed by Ulam of the Los Alamos Scientific Laboratory in 1947, and is now under active detailed study both at LASL and at General Atomic. The larger effort is along more prosaic lines, however. The possibilities of using a steady-stage heat-exchange reactor for rocket propulsion is the motivation for the LASL Kiwi-A experiment, at present in an advanced state of assembly at the Nevada Test Site.

For a perspective on the possibilities and limitations of nuclear energy for rocket propulsion, it is instructive to examine a spectrum of propellant materials such as is shown in Table 1. Referring to the column of energy densities, the first obvious remark is that the fission of $U^{235}$ yields $10^7$ times as much energy as the burning of an equal weight of a high-energy chemical combination, such as hydrogen and fluorine. This is the most spectacular energy gain in the table. Thermonuclear fusion gives another factor of ten increase in energy, but it is a somewhat empty exercise to discuss this energy source for rocket propulsion until we have some notion of what a successful man-made fusion reactor looks like. (We have a working thermonuclear reactor in our own sun, and its radiations in fact provide an attractive means for space flight in our solar system. That is another story.) Even the complete annihilation

**This article (available as IAS Report No. 59-24) is a slight condensation of the author's verbal presentation before the Propulsion I Session, IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959.**

**The author is a Staff Member, Los Alamos Scientific Laboratory.**

of matter, were it possible, yields only an additional factor of $10^3$ in energy over nuclear fission.

## Types of Motors

The foregoing figures reveal the ultimate potentialities. The actual performance of a steady-state fission rocket motor is determined not so much by the total energy available as by the temperature at which it is liberated. The heat of the reactor must be transferred to the best possible working fluid, which then becomes the rocket propellant. The best rocket propellants for nuclear propulsion are those of lowest molecular weight, which immediately implies the use of hydrogen or a material which is largely hydrogenous. Table 1 shows the propulsion properties of hydrogen at three significant temperatures. High-temperature undissociated hydrogen, dissociated hydrogen, and ionized hydrogen are states which we can hope to achieve in fission reactors with solid, liquid, and gaseous cores, respectively.

A more graphic index of comparative rocket performance is given by the column of ideal mass ratios required for escape from the earth. For this mission, a single-stage solid-core nuclear-hydrogen rocket is possible, while the competitive chemical system clearly must be multiple-stage. A nuclear rocket motor will have all the equipment and appurtenances that a chemical motor has and, in addition, the rather large mass of the reactor itself together with its control mechanisms. A substantial fraction of its gain in mass ratio over chemical systems must be sacrificed to this consideration. In spite of this, for delivery of large payloads over ranges requiring large velocities, the nuclear system may be of quite reasonable size, while the chemical system required for a comparable mission, though not impossible, will be enormous.

It is unfortunate that hydrogen provides the best propulsive performance in a nuclear heat-exchange rocket because in almost all other respects it is quite unpleasant. Since liquid hydrogen boils at −253°C. and has a density only 7 per cent that of liquid water, one has first a severe cryogenic problem, and second the implication that the rocket propellant tank must be large in volume. Alternative hydrogenous propellants, while superior from cryogenic and density standpoints, have other drawbacks. Of the hydrocarbons, methane has the largest proportion of hydrogen; but when methane is heated to high temperature, it undergoes pyrolytic decomposition and deposits large amounts of solid carbon. This is intolerable in a nuclear heat exchanger. Another propellant candidate, ammonia, does not have this defect, but the average molecular weight of its decomposition products at high temperature is so large that the area of nuclear rocket superiority recedes to even larger payloads and mission velocities.

Table 1
Materials for Rocket Propulsion

| Material | Energy Density (ergs/gm.) | Exhaust Velocity* (km./sec.) | Mass Ratio† |
|---|---|---|---|
| $2H_2 + F_2$ | $6.6 \times 10^{10}$ | 3.6 | 19 |
| $H_2$ (3,000°K.) | $4.9 \times 10^{11}$ | 9.8 | 3.2 |
| H (5,000°K.) | $3.2 \times 10^{12}$ | 26 | 1.5 |
| $H^+ + e^-$ (25,000°K.) | $2.2 \times 10^{13}$ | 67 | 1.2 |
| $U^{235}$ (fission) | $8.3 \times 10^{17}$ | 13,000 | 1.001 |
| $4H \rightarrow He$ | $6.4 \times 10^{18}$ | 37,000 | 1.003 |
| Matter | $9 \times 10^{20}$ | 300,000 | 1.00003 |

* Ideal velocity obtained in adiabatic expansion to zero pressure.

† Ratio of vehicle take-off to burnout mass required to achieve burnout velocity of 11.2 km./sec., the earth escape velocity.

While the burning propellant in a chemical rocket motor is hotter than the solid structure with which it is in contact, the reverse is necessarily the case in a nuclear solid heat exchanger. The reactor core materials must simultaneously have high melting point, strength, and thermal conductivity; be chemically compatible with the propellant; and have acceptable nuclear properties. Materials having these properties in some degree include graphite, tungsten, molybdenum, tantalum, and a variety of metallic oxides, carbides, and nitrides. With available materials, one is limited to propellant temperatures of the order of 3,000°K.

Temperatures appreciably above 3,000°K. may be accessible by the use of a molten reactor core. Here the principal problem is to obtain efficient heat transfer to the propellant and, at the same time, to retain the fissioning fluid. In the temperature range between 3,000° and 5,000°K. hydrogen at high pressure absorbs large additional amounts of energy by dissociation. The resulting two-and-a-half-fold increase in ideal exhaust velocity provides a strong incentive for attempting to operate a reactor in this temperature range.

To obtain propellant temperatures above 5,000°K., the fissioning reactor core must be gaseous. This is a region beyond anything in present-day technology. While the nature and degree of success of any device of this kind will depend in detail on engineering principles not yet developed, certain fundamental difficulties can be recognized. The conclusions of theoretical studies may be summarized by stating the three major lines of possible approach. First, fissile material and propellant might be conducted into a critical chamber, reacted to high temperature, and ejected together. Since there seems to be no way to fission more than a very small fraction of the active material in any scheme of this kind, a single mission would involve the expenditure of formidable masses of fissionable material. Second, this objection might be met if the motor incorporated a process of continuous molecular separation of the unspent fuel from the hot propellant. The unmixing of large flows of gas mixtures with compact machinery is notoriously difficult. Finally, the propellant might be conducted through a chamber containing the fissioning gas in such a way that little or no mixing occurs, the energy being transferred to the propellant by the flow and absorption of thermal radiation. But

such a strong gas flow without mixing is intrinsically unnatural. Some ingenious method of stabilization against mixing would be required. At temperatures of the order of 10,000°K. the fissioning gas core would be in the plasma state. Electromagnetic manipulation of the gas is then available as a possibility.

### Improving Performance of Solid Core Motors

For present progress, reality compels us to concentrate our attention on solid-core heat exchangers. It is appropriate to inquire if we can coax extra measures of performance from them without demanding higher materials temperatures.

One possibility lies in the recognition that reduction in pressure of high-temperature molecular hydrogen favors endothermic dissociation into atoms and thus increases the energy density of the propellant. For hydrogen at 3000°K., the effect is appreciable only at pressures substantially below one atmosphere, so that it could be exploited only at high altitudes. Of course, to obtain an increase in propellant exhaust velocity, recombination into molecular hydrogen must occur in the nozzle expansion. The design of a single reactor motor that could operate at high chamber pressure and thrust during a ground take-off and subsequently reduce chamber pressure for improved performance at altitude would be a challenging and rewarding effort.

It is often proposed that chemical afterburning of propellant preheated in a nuclear reactor might be advantageous. This is not the case if the propellant is hydrogen at 3,000°K. because the high molecular weight of any possible oxidant more than offsets the benefit of the increment of chemical energy. However, if one chooses to avoid the cryogenic and density problems of liquid hydrogen by using ammonia as the propellant, then an increase in exhaust velocity of perhaps 30 per cent might be obtained by afterburning with oxygen. Whether this gain would be worth the considerably increased complication of the motor could be determined only by attempting to design and operate such a system.

The use of quasi-isothermal expansion is another possibility for improved performance. In a conventional nuclear heat-exchange rocket motor, heat is added to the propellant until it is brought almost to the temperature of the reactor core, and then this heat energy is converted into the kinetic energy of a propulsive jet by an adiabatic nozzle expansion. In the nozzle the static temperature of the gas falls. If now the nozzle wall is maintained at high temperature by incorporating it as part of the reactor core, one has the possibility of adding additional heat during expansion. The ideal to be approached is an isothermal rather than an adiabatic expansion. Additional heat cannot be added to the propellant by convective heat transfer when the gas recovery temperature exceeds the nozzle wall temperature, and it is just this condition which must be realized in order to have a useful quasi-isothermal expansion. The required new mechanism is radiation heat transfer. Unfortunately, no practically useful propellant alone will absorb in appreciable amounts the thermal radiation emitted by the nozzle wall. The deficiency is best remedied by dispersing in the propellant a dense smoke of small refractory particles, which are borne with the accelerating gas and maintain a temperature only slightly above the gas static temperature. Improvement in exhaust velocity by 50 per cent, using this method, does not seem out of the question.

### Nuclear-Electrical Power Plant

Many proposed schemes for getting extremely high jet velocities to propel spacecraft with milli-*g* accelerations require a lightweight source of electrical power. The desirable specifications for such a power plant are discussed in another paper in this session.

N-Division at Los Alamos has a very active program of fundamental research which promises to lead to a nuclear electrical generator of most unconventional type, and of characteristics particularly appropriate for space propulsion application. The avenue of approach, called the plasma thermocouple,* depends on the fact that, when a thermally ionizable vapor is introduced between a hot electron emitter and a cold collector, potentials amounting to millivolts per degree temperature difference are generated. In addition, the cell so formed has low internal impedance. Heat-to-electrical conversion efficiencies of 30 per cent or better are theoretically possible.

A nuclear reactor incorporating an array of plasma thermocouples could, in a single unit without moving parts, embody all the functions of heat source, boiler, turbine, and generator of more conventional power plants. At low power levels, total power-plant weights, including radiator for dumping waste heat, may be of the order of 5 kg./kw. At electrical power levels above one megawatt, an improvement to 1/2 kg./kw. may be possible.

### Evolution of a Nuclear Rocket Motor

We do not yet know how, in fact, a successful nuclear rocket motor comes into being, but we have learned a lot about the early part of the story, and many of the problems and procedures of the future are clear.†

The planning and execution of this experiment to date have convinced us, if we needed such conviction, that the development of a flying nuclear rocket motor is going to be expensive and demanding of talent and hard work.

There is no such thing as a small test in the nuclear rocket motor development business. Kiwi-A, a modest experiment, has been in planning since January, 1957, in construction since January, 1958, at substantial

* G. M. Grover, D. J. Roehling, E. W. Salmi, and R. W. Pidd, *J. Appl. Phys.*, Vol. 29, p. 1611 (1958).

† The background and conduct of the Kiwi-A test has been described in *Nucleonics*, July, 1958, by Dr. R. E. Schreiber, N-Division Leader at LASL.

cost, quite exclusive of reusable test facilities. Large size is a characteristic of any nuclear reactor developing nontrivial power for appreciable periods of time. No engineer could confidently predict that an intelligently scaled-up version of a small chemical rocket motor operate precisely as predicted. But at least the small motor can exist, and has the majority of the properties of the large motor. In contrast, any meaningful nuclear rocket reactor test is a considerable undertaking.

The flux of neutrons and of gamma rays and the precise distribution of heat generation by fission fragments are environmental conditions uniquely peculiar to high power density fission reactors. They cannot be simulated except in such a reactor. This means that adequate component testing, especially of vital core and peripheral elements, is essentially impossible. Reliance must be placed on theoretical synthesis of many partial experimental component tests. The heat generation in solid-core parts is the most important single factor to be simulated in component testing. This is best done by electrical joule heating, but the technique leaves much to be desired.

A nuclear rocket motor, once run at high power and temperature, is an irrevocably different object than before test. The inelastic deformations resulting from stresses of thermal origin and due to gas flow, the small but hard-to-eliminate corrosive chemical reactions between core elements and propellant, the depletion of fissionable materials, the accumulations of nuclear poisons, the induced radioactivities—are all factors contributing to permanent change. No sensible purchaser of a large chemical rocket motor would accept a unit without assurance that it had been tested repeatedly at full power without significant change. A completely analogous shakedown procedure is, in principle, impossible for a nuclear rocket motor. Fortunately, the potential performance margin of nuclear systems may permit them to devote mass to component ruggedness or redundancy and so considerably improve the a priori reliability of the motor. What the final solution of this important production testing problem will be, however, is obviously still obscure.

Since a nuclear rocket reactor will be an expensive piece of machinery, great saving would result if it were possible to reuse the motor after a mission. There are reasons to believe that this will not in general be practical, in spite of the cost. One does not simply shut off a solid-core nuclear rocket motor after use and expect it to survive. The induced radioactivity will produce heat at a rate sufficient to require substantial flow of coolant for some days, in order that the reactor not burn itself up.

In a reactor experiment like Kiwi-A, the intent is to confront engineering principles with reality. But, as chemical rocket scientists well know, rockets often fail for small irrational reasons which have nothing to do with the soundness of engineering principles. The operation of a large device is a test almost as much of care, thoroughness, and plain good luck as it is of basic design. Because tests in the development of a nuclear rocket motor are so expensive, and because of the essential one-shot nature of a power run on a given reactor, even more attention must be given to an appalling myriad of details than is the practice with chemical rocket motors.

The gap between what now can be done confidently in reactor design and what must be done to develop a flying nuclear rocket motor is a large one. The Kiwi-A experiment, for example—even if only partially successful—can signal a major advance in gas-cooled reactor technology. Yet, if it is an outstanding success, it will represent only a first but important step toward the ultimate goal.

When the earliest flying nuclear rocket motors are made, we should not expect them to be spectacularly better in performance than chemical systems. But chemical systems are rapidly approaching the upper limit of their available energy spectrum, while the nuclear system still uses only a small fraction of its available energy. The energy is there, and we will find ways to convert it more efficiently to jet thrust. The nuclear bomb and the nuclear submarine are objects qualitatively different in kind of performance than their chemical counterparts. We may hope, by building one modest quantitative improvement on another in the years to come, one day to make the same statement of the nuclear rocket.

✦ ✦ ✦

## The Cone-Sphere in Hypersonic Helium Above Mach 20 (Continued from page 34)


[6] Probstein, Ronald F., *Inviscid Flow in the Stagnation Point Region of Very Blunt Nosed Bodies at Hypersonic Flight Speeds*, WADC TN 56-395, Sept., 1956.

[6] Heybey, W. H., *Shock Distance in Front of Symmetrical Bodies*, U.S. Naval Ordnance Lab. Report No. 3594.

[6] Van Dyke, Milton D., *The Supersonic Blunt-Body Problem—Review and Extension*, Journal of the Aero/Space Sciences, Vol. 25, No. 8, pp. 485–496, Aug., 1958.

[7] Johnson, Robert H., *Blunt Bodies in Hypersonic Helium Above Mach Number Twenty*, Ph.D. Thesis, Rensselaer Polytechnic Institute, Troy, N.Y., June, 1958.

[8] Taylor, G. I., and Maccoll, J. W., *Air Pressure on a Cone Moving at High Speeds*, Proc. Roy. Soc., Vol. 139, 1933.

[9] Schwartz, R. N., and Eckerman, J., *Shock Location in Front of a Sphere as a Measure of Real Gas Effects*, J. Appl. Phys., Vol. 27, Feb., 1956.

[10] Blackman, V. H., *Vibration Relaxation in Oxygen and Nitrogen*, J. Fluid Mech., Vol. 1, No. 1, May, 1956.

[11] Bogdonoff, S. M., and Vas, I. E., *Experimental Studies at Mach Numbers 11 to 19 of Conical and Blunted Bodies at Zero Angle of Attack*, Princeton University, Report No. 435, Sept., 1958.

*Since man's primary role in the spaceship will be to make decisions, "the considerations should be not how much man can take, but what is the proper environment in which his efficiency will not deteriorate."*

# Man-Machine Integration in Space Vehicles

Comdr. George W. Hoover, USN
Department of the Navy

WHEN THE first flight of an aircraft was made by Orville Wright on December 17, 1903, he was wearing an ordinary business suit. As engineers progressed in the development of the aircraft, their ingenuity in creating higher performance placed a continually mounting series of burdens on the pilot. As the velocity increased, the pilot was forced to wear helmet and goggles. As the operating ceilings went up, it became necessary for the pilot to bundle up in very warm flying suits with heavy boots and gloves. Along with the increased altitude capability came more impairment, the oxygen mask, and, as the performance went up, it became essential to develop the *g*-suit, the survival suit, and then the pressure suit.

In every instance, the design of protection equipment of the pilot came after the situation had been necessitated by increased aircraft capability. One of the most apparent characteristics of each of these protection devices is that they were all designed to be functional when in contact with the body rather than to be integrated into an environment surrounding the operator. Every effort was made to ensure maximum comfort for the individual, but comfort was a secondary requirement since protection had to be effected. The situation which exists, however, is that the pilot is protected, he is not comfortable, he is not operating in his natural environment, and therefore his performance is definitely impaired.

Such has been the case, to a degree, not only in aircraft but in almost every type of machine. The vehicles continually increased in performance, and the consideration of the operator has always lagged behind, usually resulting in a compromise in order to meet the operational deadline.

Even in the missile program, it is noticeable that the manned portion of the operation, the countdown and preparation procedures, have to a certain extent lagged behind the actual missile design.

In other words, we have always had to fit the man into an already existing machine, or one too far along in design to change, usually at the expense of the comfort and performance capability of the operator.

Such a procedure has almost reached a point of saturation wherein the objective of the machine is being compromised because adequate provisions have not been made for the operator.

A high-performance aircraft, for instance, may be the finest machine in its class from an operational capability standpoint, but, since performance is a product of the man and the machine, unless the pilot is adequately provided for, the operational objective will never be fully achieved *Man's requirements must be placed on an equal level with those of the machine—and particularly in the spaceship if we are going to be successful in this new endeavor.*

Before we can establish the space pilot's requirements, we must first determine man's role in the overall space man-machine complex. Is he to play an active or a passive part in the total operation?

It can be shown that any machine operation can take place only as a result of a man-made decision. Even the most completely automatic system requires a man-made decision to incorporate intelligence within it, to set it in motion, or to change its program. It is evident, then, from this that man's primary role in the spaceship will be to make decisions.

Let us consider for the moment some of the present designs for man's first step into space and try to analyze (1) the objective for which these systems were designed, (2) man's role in these systems, and (3) the methods for meeting his environment requirements.

---

**This article is a condensation of the author's paper, of the same title (available as IAS Report No. 59-51), presented at the Medical and Psychological Problems of Man in Space Session, IAS 27th Annual Meeting, N.Y., Jan. 26–29, 1959.**

**The author is Manager, Weapons Systems, Air Branch, Office of Naval Research.**

A fine example of the advances being made to place a man-machine system into space is the X-15 project. This project represents a substantial step in the right direction. In it, the aircraft engineers have developed an excellent set of performance characteristics for the vehicle. More than that, the human engineers have done a fine job of working into the system substantial protection for the pilot. However, it should be pointed out that this is still but an initial step, even though well-directed—and the ladder to space has many more difficult rungs to climb.

Basically, we have in the X-15 the first vehicle with a capability of going essentially beyond the earth's atmosphere (Fig. 1). Quoting from a press release (DOD #975, Oct. 4, 1958) on the X-15, the project's research objectives are described as follows (Fig. 2):

"*Primary* research interest of the X-15 is to obtain knowledge of actual flight conditions beyond the earth's atmosphere, aerodynamic heating and heat transfer, and the measurement of heat on structural components.

"What is needed is knowledge of control requirements at low dynamic pressures found at extremely high altitudes and the determination of applications of the two control systems during a typical mission.

"Third, *and perhaps the most important*, is the wealth of information which can be obtained from repeated missions involving exit from and entry into the earth's atmosphere.

"Finally, only man can prove how man will react to space flight. How will he react to weightlessness, acceleration, and deceleration? The X-15 test program will provide the answers."

Now these are very logical objectives because they will permit the study of transition from aerodynamic control to ballistic control and the problems of re-entry.

The pilot's role in this device is obviously active because he will be controlling the ship during the entire flight, assisted of course by automatic equipment.

Continuing to quote from the research objectives:

"It is the conclusion of this and other human factors research that man is not a limitation to high-speed, high-altitude flight such as will be experienced in the X-15. In step with this conclusion, human factors engineers have provided *maximum protection* for the pilot while in performance of his research mission.

"In the event of any unforeseen emergency even at these altitudes, however, the entire ship itself will be utilized as an escape capsule to penetrate the atmosphere. Once within the denser atmosphere, a conventional ejection would be possible even at altitudes of 60,000 ft. The pilot's pressure suit will provide breathing oxygen, a compatible pressure environment, and wind blast protection during ejection. A newly developed, stabilized ejection seat will prevent tumbling at excessive *g* forces. Separation from the seat and operating of the parachute, as has been proven in other human factors tests, will be automatic."

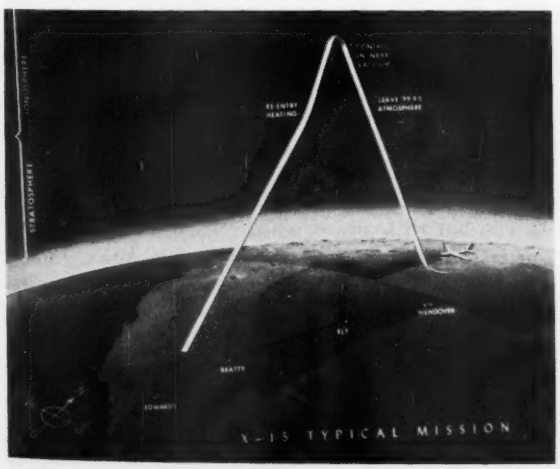



FIG. 1.

FIG. 2.

Pausing for a moment to consider the pilot's environment, it is here that we can note certain requirements for further progress before true man-machine integration will be achieved. Some of the best brains in the business are hard at work devising even better systems to supersede the X-15, and it seems fairly certain that such are within reach, even if not immediately within grasp.

From the above it is apparent that the word *protection* is stressed, as it should be, but, looking at the equipment (Fig. 3) to be worn by the pilot, it is also apparent that the pilot's performance may be impaired to a considerable degree. His instruments and controls, which are essentially conventional, will require him to continuously mentally integrate many bits of information in order to perform his mission. Since the duration of the flight is short, and considering the number of functions the pilot must carry out, it seems evident that the pilot will be forced to operate at maximum efficiency during the entire flight. This efficiency will be somewhat lowered because of his impairment not only physiologically but psychologically since there will be concern over escape during the flight, and the escape capability, even with an ejection seat, is at best marginal during certain periods of the flight.

None of these statements are meant to indicate that the pilots of the X-15 will not be able to make these first probes into space; nor are they intended to be hypercritical of any of the system's design. On the contrary, the X-15 represents a good starting attack on the problems of manned space vehicles. But remember that the X-15 is fundamentally designed to get a man a short distance into space, for a very short period of time, and to get him back—and to keep him

alive during this process. We must carefully avoid considering this step as the ultimate solution to the problem of man-machine integration. The goal must continue to be that of getting man into space and—at the same time—enabling him to *work constructively* while he is out there.

But now, since our sights must be set a little higher than just sticking our nose into space, we cannot meet the pilot's environmental requirements for extended space flight with just another series of compromises. Once we go beyond the probe stage, the distance from our natural environment will be much greater, the hazards will be more extreme, the external environment will be more challenging, both physiologically and psychologically, and the forgiveness of errors of judgment will be almost zero.

Now let us look at one of the more advanced designs for actually putting man into space. This is known as Project Broom (Ballistic Recovery of Orbiting Man).

We have to ask ourselves seriously, "What is the real objective of this proposed machine?" If it is merely to put man into space and bring him back for propaganda purposes, then the objective is perhaps valid. But what could we really learn from sending a man out in a completely passive state (or almost passive), other than the fact that he was able to take it? The pilot with regard to his task of making decisions would not have learned anything about his problem except that it is rough. The engineer would not have learned anything from the man about how his ship performed, except whether or not it returned. And, if we learn anything from a physiological or psychological standpoint, we would have been using a rather expensive guinea pig.

FIG. 3.

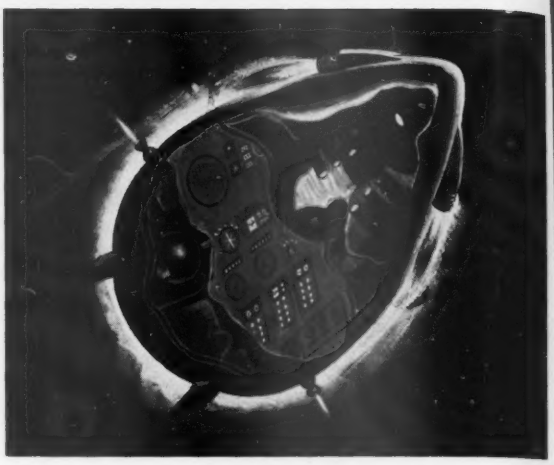


FIG. 4.

As to the environment, again in this design it appears that many compromises still exist, such as encapsulating the pilot in a pressure suit, strapping him in a supine position, and forcing him to accept completely the reliability of a programed computer and guidance and control system with no capability of being able to correct for unforeseen deviations from the preplanned trajectory except for the most critical part of the flight, the re-entry. But again, here is another step in our progress toward the stars, and there will undoubtedly be much more thought given to this project before it shows up in the form of actual hardware.

Keep in mind that the real objective of a space flight program is to permit man to *operate* in space, and in order to do so he must be given every possible consideration. His environment requirements must be given equal consideration with those of the vehicle itself. It is certain that in the vehicle we will spare no expense in studies and experiments to wring the last ounce of performance from its design capabilities. We cannot, therefore, spare any expense in establishing those conditions necessary for providing an environment in which we can get maximum performance from the man.

I am not suggesting that there is no place in the program for this type of machine. In the case of the X-15, this is a logical extension of manned high-performance aircraft, and a great deal can be learned by using it as a test bed. In the latter case, however, I feel we are jumping the gun. Fire such vehicles (Fig. 4), yes, but with proper sensors, computers, and transmitters to gather data to determine three things: (1) whether or not the environmental requirements have been met, (2) whether or not the machine can be maintained, and (3) whether or not it can be controlled. Until these problems can be solved, man is not ready for the big step.

What can we do to integrate man and the space vehicle?

We must first have a logical man-machine organiza-

tion. Previous work in aircraft, submarines, and surface vehicles has indicated that there is a logical organization which consists of sensors, computers, amplifiers, displays, and controls. I am referring in this instance only to the man-machine portion of the overall spaceship. The specifications generated here will establish the requirements for the vehicle itself consisting of the structure, material propulsion, and payload. We must create, as an integral part of the man-machine system, an environment conducive to making decisions and requiring as little training and rehabilitation as possible.

The problem of determining what constitutes a decision-making environment can be divided into two tasks, although both must be closely correlated and one is no less important than the other. First is the task of determining the environmental requirements from a physiological standpoint; second is determining the requirements from a psychological standpoint.

In order for man to make sound decisions, he must operate within an environment which very closely duplicates that found in his terrestrial home. With this terrestrial environment as a yardstick, we must determine the following physical parameters, and the considerations should be not how much man can take, but what is the proper environment in which his efficiency will not deteriorate:

| | |
|---|---|
| Pressurization | Acceleration |
| Ventilation | Vibration |
| Atmospheric composition | Noise |
| Humidity | Illumination |
| Temperature | Radiation |

We must determine the following metabolic requirements (these are examples, not a complete list): food, water, waste disposal, and the work/rest cycle.

The definition of these requirements cannot be in general terms but rather in specifics because they will be used as the limiting factors by the engineers in order to design the enclosure for this environment. There can be few or no approximations because successful design of the entire spaceship will depend upon their accuracy.

Here the experimental investigation should *not* be made by first placing *subjects in boxes or confined spaces and observing what happens to them*, but instead by observing and tabulating man's ability to make decisions in his everyday environment, and then by analyzing the composition of this environment. Speaking of placing men in boxes, we already have one of the finest test beds available for these environmental experiments in our submarines capable of staying submerged for as long as 60 days, not to mention our high-altitude balloon gondolas. Only after we have determined what this everyday environment really is can we design controlled experiments in which factors are varied in order to determine the point at which performance in making decisions begins to drop off. This of course must be determined by simultaneously considering the psychological factors. From these experiments we can then determine not only *what* environment must be established but within what limits it must be maintained, and, in addition, how it must be controlled. The objective or goal of this initial study must be to duplicate, rather than approximate, the normal terrestrial environment. Such an approach does not suggest that the design of spaceships must wait until a means of duplicating terrestrial environment is found, but, by seeking the ultimate, less compromise will be made for interim design, the area of compromise will be clearly defined, and areas for further research will be better established.

The second task of determining the psychological requirements is perhaps the more difficult because the objective of these studies will be to define the factors which contribute to keeping man mentally stable in order to function efficiently in the total system.

The first step must be to determine the requirements for establishing and maintaining minimum emotional stress, maximum morale, sufficient relaxation, and adequate habitability.

Consideration must be given to such factors as noise, color, lighting, odors, and others which contribute to "happiness" in everyday living. To establish these requirements, man must be observed in his "terrestrial home"; his habits, needs, desires, recreation, etc., must be tabulated and analyzed to determine these factors which contribute to or detract from emotional stability, and the degree of importance of each. We must determine, for instance, whether or not music is fundamentally required, what types of diversion from primary tasks are needed, and what he gains from pursuing hobbies. These must then be plotted against time in order to define the design requirements for duplication or satisfactory equivalents. Such studies must be conducted for solitary individuals, as well as groups or communities. Once these parameters are determined, experiments can then be designed to again measure psychological performance deterioration by varying the factors and observing the effects.

Man has proved himself capable of making sound decisions, but in order to do this he must be given adequate information along with a proper environment. He is a part of a man-machine system in which data must be sensed, computed, and displayed in an inte-

FIG. 5.

grated form in order that he can act upon them through properly designed controls. Such a system must be inherently automatic—but monitored by the man. If any portion of the system is inadequate, then the man cannot be adequate in making his decision because he makes decisions by use of the information he receives from *all* of his sensory systems.

Man does not adapt himself too quickly to a loss of any one of his senses, nor does he operate efficiently if any of his senses is impaired. Pilots flying instruments are continually plagued by a conflict between what they see and what their vestibular and proprioceptive sense is telling them. There are literally reams of evidence to prove that even a slight modification of stimuli, such as occurs in the case of instrument flying, results in improper decisions, with a large percentage fatal; and space flight will be done completely on instruments.

Such evidence indicates then that it is imperative that, if man is going to extend his capabilities to operate in space, he must retain full use of all of his senses and therefore cannot tolerate any environment which differs significantly from that in which he evolved. *In space there can be no mistakes, no aborted flights, and no forced landings.*

It is essential then that the pilot of the spaceship be given the proper information and the proper controls if he is to operate successfully. I am not in a position to state just what the instruments and controls of the spaceship will be, but, from previous research conducted on aircraft, submarines, and surface ships, I am convinced that the same basic requirements must be met. The spaceship from the control standpoint is just another vehicle operating in a new medium, or perhaps I should say lack of a medium. It can be considered as a combination of the aircraft, submarine, and missile.

The problem is essentially the same as any other because the pilot is still taking his ship from point A to point B, and, since man has learned (Fig. 5) to orient himself with respect to a ground plane or surface in his terrestrial environment, he must be provided with a

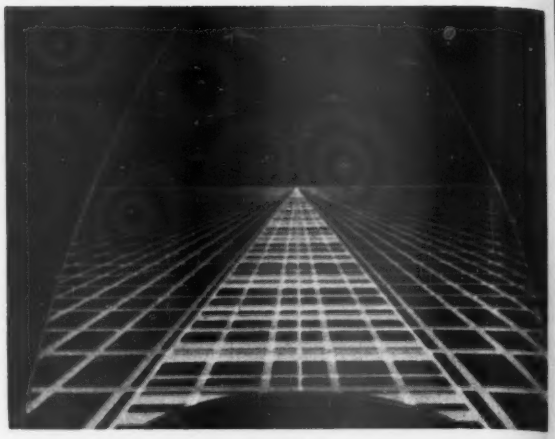


FIG. 6.

visual presentation of a theoretical plane in space established between the earth and the destination. "Up" would then be vertical to this plane. Superimposed upon this plane would be the flight path which would represent the trajectory or actual flight path (Fig. 6).

In summary, I am suggesting that in the spaceship we give more consideration to the crew than we have in previous vehicles. Let us not just build a ship with adequate performance capabilities and then, almost as an afterthought, remember that we must have personnel to operate it. This time, let us build the ship to fit the man—one with an environment which provides the operator with the proper display of required information so completely integrated that he can perform as a link in the system, which will not have redundancy except where it is an asset, which will require an absolute minimum of maintenance and permit in-flight repair, which will be a total man-machine system, and which will permit complete survival under any emergency.

Given this environment, man can operate his spaceship with maximum efficiency, maximum comfort, and a minimum of emotional stress—for long periods of time, to almost any distance.

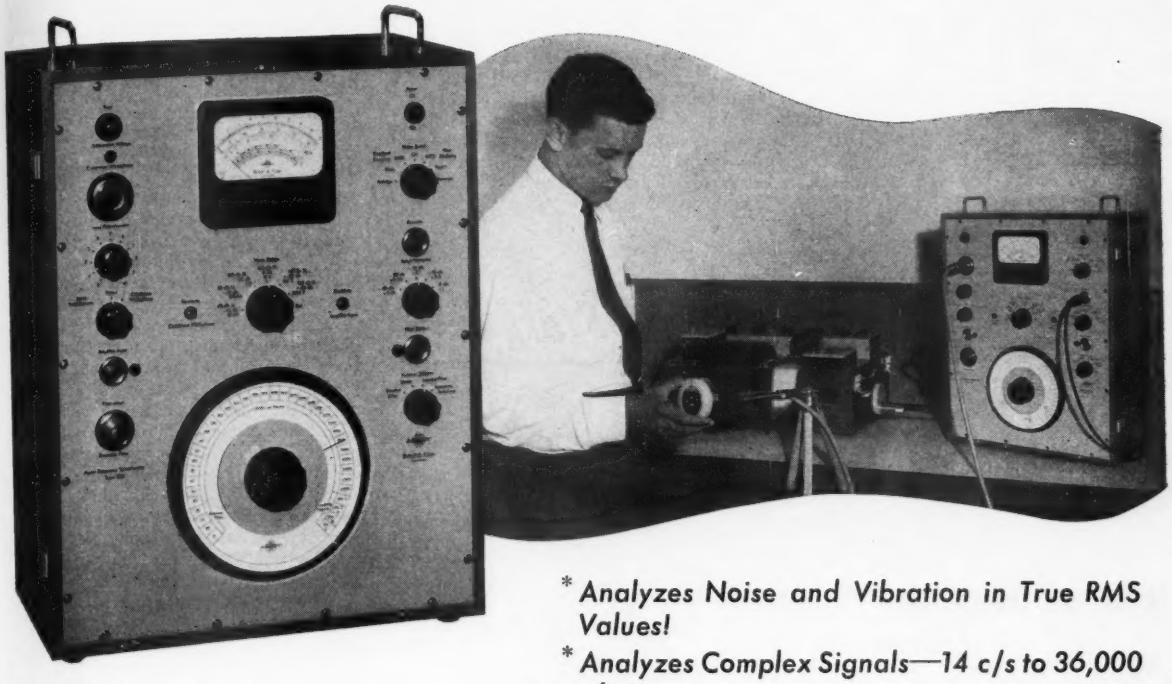
## The Space Age Effect on Management (*Continued from page 29*)

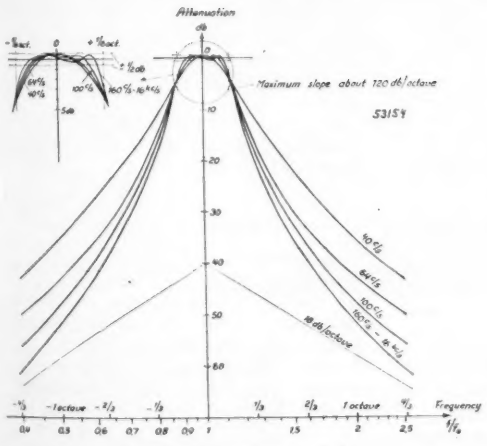
well as service, personnel to take courses taught on the base by the Ohio State faculty. Similar provisions have been made with other universities near Army and Navy installations for the same commendable purpose.

The entire field of space technology has been romanticized in the manner of a Jules Verne novel stressing the possibilities of mass transportation to the moon and the closer planets of our solar system. The major problems of reliability of the various components and systems, and the ability to duplicate performance in the military weapons, have been pointed up primarily in the field of failures of the systems to achieve their objectives, without paying tribute to the steady progress toward a successful achievement of the targets established by the Armed Services and NASA. The role of the scientist is being emphasized more than that of the engineer. This may seem to be far from the subject of "The Space Age Effect on Management," but I feel that the youth of today are being influenced to a far greater extent than we may realize and that enrollment in the basic sciences instead of engineering will increase, bringing on new problems in the not-too-distant future when we may find ourselves with an abundance of physicists, biochemists, mathematicians, etc., and a dearth of engineers of all kinds without whom the applications of the discoveries of the scientists would be of practically no value.

The problems are many and varied. The solutions are in the process of being achieved. The period between promises to be most interesting and vexing to all.

# *New* . . . Bruel & Kjaer 1/3 Octave SPECTRUM ANALYZER






*Detailed filter characteristics.*

- *Analyzes Noise and Vibration in True RMS Values!*
- *Analyzes Complex Signals—14 c/s to 36,000 c/s.*
- *Analyzes Signals from 5 Micro Volts to 1000 Volts.*
- *Combines with the B & K Level Recorder for Automatic Analysis and Data Plotting.*

The new Audio Frequency Spectrometer Model 2110 features switch selection for either a true RMS, average or peak reading of analyzed data. The RMS indication is most frequently preferred for noise and vibration measurements because of its direct relation to the energy of the signal being measured.

The new model 2110 has thirty 1/3 octave band filters to extend the frequency range for complex signal analysis to be from 35 c/s to 36,000 c/s. Optional 1/3 octave filters may be added to extend the low frequency range down to 14 c/s. The spectrometer can be mechanically switched by the level recorder Model 2304 for automatic measurement and recording of spectrograms on frequency-amplitude calibrated chart paper.

*Write now for complete information on B & K 2110!*

***Exclusive Franchised U. S. Marketing Agent for Bruel & Kjaer Instruments***

Gentlemen:
Please send me information on the B & K Model 2110

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

B & K INSTRUMENTS, Inc.
3038 W. 106th STREET • CLEVELAND 11, OHIO • CLearwater 1-8430

quarterly cumulated volumes and an annual volume, all in book form, also are available.

Bound volumes include the uniterms in alphabetical order with accession numbers of the indexed articles, an alphabetical list of authors, and a list of accession numbers and complete citations for corresponding articles.

The service is available in part or entirely; the cost of the annual volume, which will be available early in 1959, is $25.

Inquiries may be addressed to the Library at 7660 Beverly Boulevard, Los Angeles 36, Calif.

### Columbia University Honors A/SE Adviser

Major Gen. John B. Medaris, Commanding General, U.S. Army Ordnance Missile Command, has been awarded the Michael I. Pupin Anniversary Medal by Columbia University for distinguished service to the nation. This is second in a series of medals awarded during the 100th anniversary year of the birth of Michael I. Pupin, Columbia University engineer, teacher, and inventor.

General Medaris is a member of this magazine's Editorial Advisory Committee and serves on its Space Technology Panel.

## *Meet the Staff*

**An Aero/Space Engineering feature on personnel of the Institute of the Aeronautical Sciences**

## John J. Glennon— *Librarian*

John J. Glennon came to the Institute in September, 1939, when its collection of technical publications consisted of only slightly more than 1,300 volumes. They were housed in IAS offices on the 51st floor of the RCA Building. Today, as Librarian, he is responsible for some 75,000 volumes and reports at IAS National Headquarters on East 64th Street in New York City.

Mr. Glennon, in addition to being Chief Librarian, is Editor of the annual *Aero/-Space Engineering Index* and Book Reviews Editor of the Institute's official monthly publication—*Aero/Space Engineering*. He is in complete charge of both the strictly library activities in New York and also the Abstracts Section, which was put into the Library organization in 1956. (The group prepares the Aeronautical Reviews and International Aeronautical Abstracts sections for *A/SE*.) In 1957, he was directly concerned with the preparation of German and French editions of IAA for distribution in Europe by EOARDC.

Mr. Glennon, who occasionally finds time to translate into English U.S.S.R. and German technical papers, is also a world traveler. He has attended NATO's AGARD Documentation Committee meetings in Canada, Europe, and the United States, as a U.S. Observer. (He also has participated in subcommittee work for this group.) He returned recently from a 5-week trip to libraries and technical information centers in the Soviet Union, Germany, Belgium, and England. Explored particularly was possible expansion of publication exchanges.

John Glennon is a member of the Special Libraries Association, of the Board of Directors of the National Federation of Science Abstracting and Indexing Services, and of the Abstract Editorial working group of the Federation.—A.B.

## Necrology

### Hans R. Friedrich

Hans R. Friedrich (AF), Assistant Chief Engineer for development at Convair (Astronautics), A Division of General Dynamics Corp., died of a heart ailment in a San Diego hospital, December 6. He was 47.

A codeveloper of the German V-2 rocket, Friedrich came to this country following the war and worked on U.S. Army rocket projects at Fort Bliss, Tex., and Redstone Arsenal, Huntsville, Ala., before joining Convair.

Friedrich was born September 12, 1911, in Zwickau, Germany. He was graduated from the University of Leipzig with a doctor of philosophy degree.

He served as a research scientist for the German General Electric Co. in Berlin from 1937 to 1939, then went to Peenemuende, where he was an associate of Dr. Wernher von Braun, technical director to the German Rocketry Center. Friedrich was in charge of developing the autopilot system, later worked on V-2 flight simulation, and subsequently was named manufacturing consultant to the entire German electronic industry with respect to V-2 engineering specifications and material requirements.

In 1945 Friedrich accepted an invitation from the U.S. Army to work on rocket and missile programs in this country. Until 1950 he was a research scientist for the Army at Fort Bliss, specializing in control and flight performance problems and preliminary design of guided missiles. He spent the following year at the Army's Redstone Arsenal, where he did preliminary design work on the Redstone missile.

He joined Convair in 1951 as a Design Specialist and was assigned to the Atlas program. In 1954 he was named a Dynamics Group Engineer and the following year became Chief Flight Mechanics Engineer for the Atlas program. In March, 1957, he was promoted to Assistant Chief Engineer for development.

He became a naturalized citizen of the United States in 1955. He was an Associate Fellow of the Institute (having become a Member in 1949), a member of the American Rocket Society and president of its San Diego section, and a member of the power-plant controls subcommittee of the NASA.

Interested in education, he had served as a Visiting Professor of Engineering at the University of California at Los Angeles.

He is survived by his wife, the former Johanna Mueller, and two daughters, Karin and Barbra.

### Samuel A. Gordon

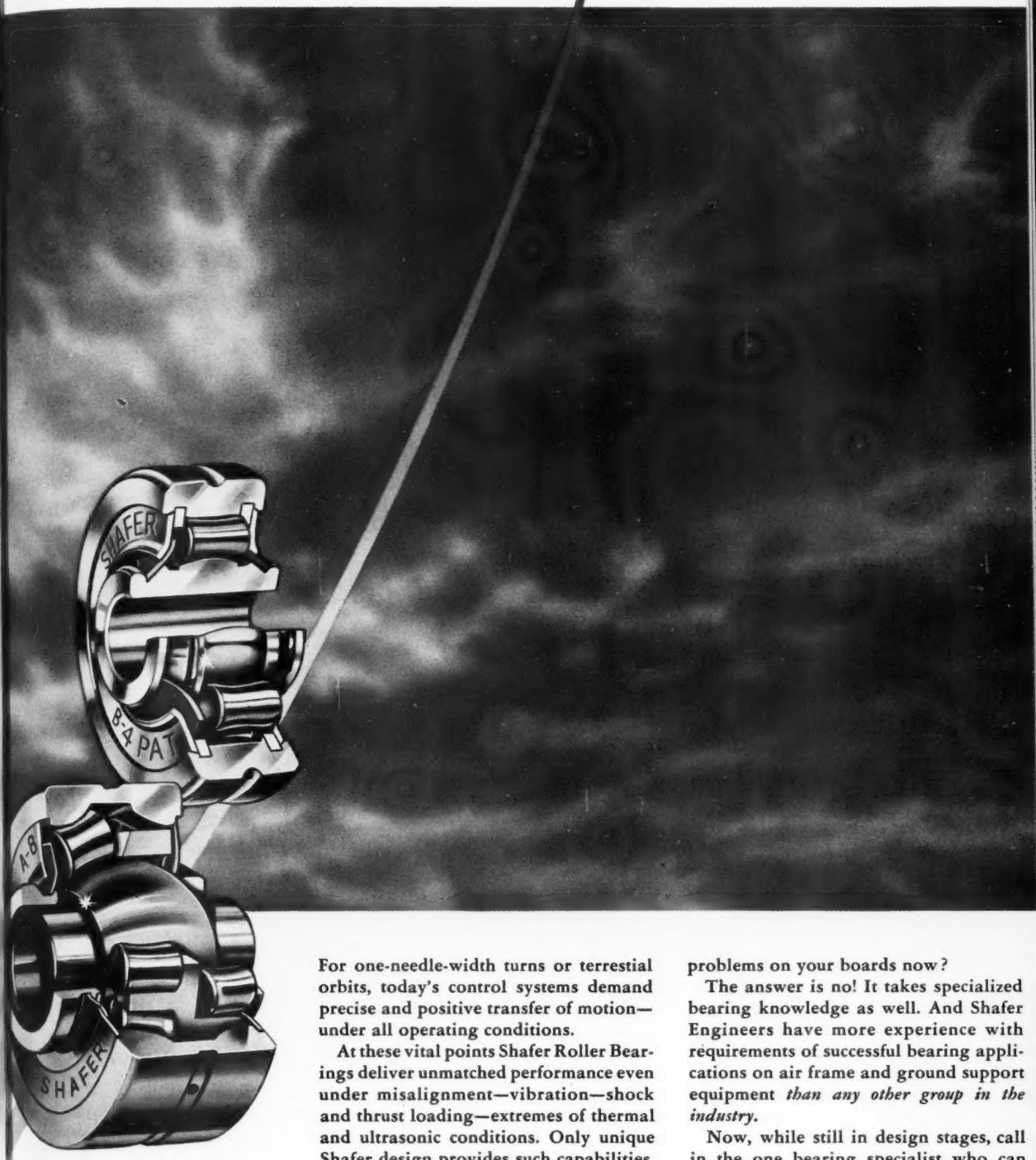
Samuel A. Gordon (AF), a Consultant with Battelle Memorial Institute, died last October 26. He was born on May 27, 1905, and received a B.S. in Aeronautical Engineering from M.I.T. in 1929. His specialty was structural design and static testing. He formerly was associated with Chance Vought Aircraft and The Martin Co.

### Norton B. Moore

Norton B. Moore (AF), consultant in engineering, specialist in jet propulsion and guided missiles, and author of numerous scientific papers, died on December 11, after a long illness. He was 49.

At the time of his death, Dr. Moore was president of Norton B. Moore & Associates, Santa Barbara, Calif. He was a prominent aerodynamicist and had worked with the major aircraft companies. He was affiliated with McDonnell Aircraft Corp., as a Consultant; Curtiss-Wright

# motion... in ultrasonic cadence




For one-needle-width turns or terrestial orbits, today's control systems demand precise and positive transfer of motion—under all operating conditions.

At these vital points Shafer Roller Bearings deliver unmatched performance even under misalignment—vibration—shock and thrust loading—extremes of thermal and ultrasonic conditions. Only unique Shafer design provides such capabilities.

*BUT* will design alone of a Shafer or any "look-like" bearing solve the many problems on your boards now?

The answer is no! It takes specialized bearing knowledge as well. And Shafer Engineers have more experience with requirements of successful bearing applications on air frame and ground support equipment *than any other group in the industry.*

Now, while still in design stages, call in the one bearing specialist who can supply the *vision* that eliminates *revision*—a Shafer Aircraft Bearing Engineer.

SHAFER® BEARINGS

**CHAIN BELT COMPANY**

Downers Grove, Illinois

# Another NEW Variac® 10-Ampere Type W10

These new Type W10 VARIACs complete the modernization of the entire VARIAC line so that all units are of the "W" type. Improvements include wrought metallic parts, better heat transfer between coil and base, and brush and radiator; improved insulation, disc radiators and generally improved mechanical design. ALL VARIACS have exclusive DURATRAK contact surfaces for longer life.

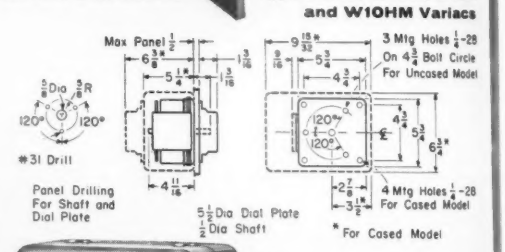
| | W10 Uncased | W10M Cased | W10MT Portable (2-wire cord) | W10MT3 Portable (3-wire cord) | W10H Uncased | W10HM Cased | W10HMT Portable (2-wire cord) | W10HMT3 Portable (3-wire cord) |
|---|---|---|---|---|---|---|---|---|
| **Input Voltage** | 115 | 115 | 115 | 115 | 230 | 230 | 230 | 230 |
| **Load Rating (kva)** | 1.5 | 1.5 | 1.5 | 1.5 | 1.2 | 1.2 | 1.2 | 1.2 |
| Output Voltage | 0-135 | 0-135 | 0-135 | 0-135 | 0-270 | 0-270 | 0-270 | 0-270 |
| Rated Current (amp) | 10 | 10 | 10 | 10 | 4 | 4 | 4 | 4 |
| Maximum Current (amp)* | 13 | 13 | 13 | 13 | 5.2 | 5.2 | 5.2 | 5.2 |
| No-Load Loss at 60c. (W) | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| Dial Calibrations† | 0-115<br>0-135 | 0-115<br>0-135 | 0-135 | 0-135 | 0-230<br>0-270 | 0-230<br>0-270 | 0-270 | 0-27 |
| Angle of Rotation (deg.) | 320 | 320 | 320 | 320 | 320 | 320 | 320 | 320 |
| No. Turns on Winding | 212 | 212 | 212 | 212 | 430 | 430 | 430 | 430 |
| D-C Resistance of Winding (Ω) | 0.63 | 0.63 | 0.63 | 0.63 | 4.73 | 4.73 | 4.73 | 4.73 |
| Driving Torque (oz.-in.) | 30-60 | 30-60 | 30-60 | 30-60 | 30-60 | 30-60 | 30-60 | 30-60 |
| Net Weight (lbs.) | 12½ | 15 | 16 | 16 | 12 | 14 | 15½ | 15½ |
| Code Word | DOGAL | DOGER | DOGIC | DOGOM | LUTAL | LUTER | LUTIC | LUTOM |
| **Price** | **$31.00** | **$44.00** | **$48.00** | **$51.00** | **$33.00** | **$46.00** | **$50.00** | **$53.00** |

*For "0 to line-voltage" connection only.
†Portable (MT-MT3-HMT-HMT3) models are wired for over-voltage connection and have corresponding dial scales. Line-voltage connection and dials supplied on special order.

Replacement Brushes: W10, W10M, W10MT(3) = Type VBT-10, $1.25. W10H-W10HM-W10HMT(3) = Type VBT-11, $1.25.

**Type W10 Variac**
115-Volt Input; 1.5 KVA; 13 Amp. Max. Current (Type W10H similar except for terminals and dial)

## Essential Dimensions

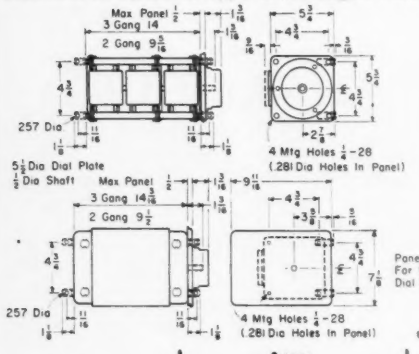



## Types W10, W10M, W10H and W10HM Variacs

### Type W10MT3

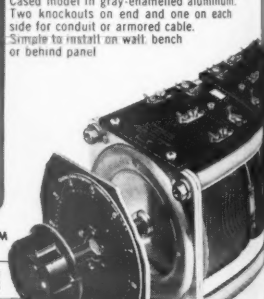
Portable model, cased, 3-wire output receptacle, ON-OFF switch, overload breaker and heavy-duty 3-wire line cord and plug. Available in 2- and 3-wire models for either 115- or 230-volt lines

### Essential Dimensions Type W10 Ganged Variacs




### Type W10M

Cased model in gray-enamelled aluminum. Two knockouts on end and one on each side for conduit or armored cable. Simple to install on wall, bench or behind panel



**Type W10G2 Variac**
2-Gang Type W10 (W10HG2 similar except for terminals and dial)

| | 2-gang W10G2 Uncased | | | W10G2M Cased | 3-gang W10G3 Uncased | | W10G3M Cased | 2-gang W10HG2 Uncased | | | W10HG2M Cased | W10HG3 Uncased | | W10HG3M Cased |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Input Voltage** | 115 | 115 | 230 | Same as W10G2 | 115 | 230 | Same as W10G3 | 230 | 230 | 460 | Same as W10HG2 | 230 | 460 | Same as W10HG3 |
| **Load Rating (kva)** | 3 (Parallel) | 2.6 (Delta) | 3 (Series) | Same as W10G2 | 4.5 (Parallel) | 5.2 (Y) | Same as W10G3 | 2.4 (Parallel) | 2.1 (Delta) | 2.4 (Series) | Same as W10HG2 | 3.6 (Parallel) | 4.1 (Y) | Same as W10HG3 |
| Dial Calibrations | 0-10 | | | 0-10 | 0-10 | | 0-10 | 0-10 | | | 0-10 | 0-10 | | 0-10 |
| Driving Torque (oz.-in.) | 60-120 | | | 60-120 | 90-180 | | 90-180 | 60-120 | | | 60-120 | 90-180 | | 90-180 |
| Net Weight (lbs.) | 26½ | | | 30½ | 39½ | | 43½ | 25 | | | 29 | 37 | | 42 |
| Code Word | GOGAL GANDU | | | GOGAL BONDU | GOGAL GANTY | | GOGAL BONTY | LUTAL GANDU | | | LUTAL BONDU | LUTAL GANTU | | LUTAL BONTY |
| **Price** | **$72.00** | | | **$93.00** | **$105.00** | | **$128.00** | **$76.00** | | | **$97.00** | **$111.00** | | **$134.00** |

ANY TYPE W10 Variac or Variac gang can be supplied with ball-bearings. Add suffix "BB" to type number and following surcharge to prices. Single unit: **$8.00** — 2-gang: **$10.00** — 3-gang: **$12.00**


GENERAL RADIO COMPANY
275 MASSACHUSETTS AVENUE, CAMBRIDGE 39, MASSACHUSETTS

NEW YORK AREA: Broad Ave. at Linden, Ridgefield, N. J. N. Y. WOrth 4-2722, N. J. Whitney 3-3140
CHICAGO: 6605 W. North Ave. Oak Park Ill. Village 8-9400
PHILADELPHIA: 1150 York Rd. Abington, Pa. HAncock 4-7419
WASHINGTON, D.C.: 8055 Thirteenth St. Silver Spring, Md. JUniper 5-1088
SAN FRANCISCO: 1182 Los Altos Ave. Los Altos, Cal. WHitecliff 8-8233
LOS ANGELES: 1000 N. Seward St. Los Angeles 38, Cal. HOllywood 9-6201
IN CANADA: 99 Floral Pkwy. Toronto 15, Ontario CHerry 6-2171


XUM

Corp., as Associate Director of Research; University of California at Berkeley, as Assistant Professor of Mechanical Engineering; and Douglas Aircraft Corp., as Aerodynamicist and Chief, Aerodynamics and Flight. Before becoming an independent consultant, he was with the Aerophysics Development Corp. as a Group Leader in aerothermodynamics.

Dr. Moore was born in Oakland, Calif., and received a Ph.D. degree, *magna cum laude*, from the California Institute of Technology in 1934, where he was Research Assistant to Prof. Theodore von Kármán.

### Frederick W. Pruden

The Institute has been notified of the sudden death of Frederick W. Pruden (M) on November 15, while en route from London to Ottawa. Mr. Pruden was Group Leader, Simulation, National Research Council, Ottawa.

He joined the Mechanical Engineering Division, NRC, Ottawa, in 1947, and his widespread interest led him to concentrate on the expanding fields of computers, data-processing, and automatic control. As a consequence, he recently set up and was in charge of the Computation and Simulation Group at the Montreal Road Laboratories.

He was born in London in March, 1922, and joined the National Physical Laboratory, Teddington, England, in 1940, working on high-speed aerodynamics problems. He received his B.S. degree in Mathematics and Physics from London University in 1945.

Besides his affiliation with the IAS, he was an active member of the Canadian Aeronautical Institute, Institute of Radio Engineers, Canadian Simulation Council, and Association for Computing Machinery.

### John Walter Wood

John Walter Wood (AF), Associate Professor of Architecture at the University of Illinois, died in December after a long illness.

Professor Wood was born in 1900 and received his B.S. degree in 1922, and his Master of Architecture degree from Harvard University in 1927. In 1923 he studied at Oxford University and at the École des Beaux Arts in Paris in 1928.

Engaged in architecture and airport design since 1931, he was architect for Air Force technical schools in Denver, consultant on airports to the Assistant Secretary of Commerce, and airport analyst for the Port of New York Authority from 1943 to 1945. He was Chief of the Layout and Safety Unit, Airport Development and Engineering Branch, at headquarters of the Army Air Force in 1945.

Holder of numerous patents, he was also author of *Airports—Some Elements of Design and Future Development*, 1940, and *Airports and Air Traffic*, 1948.

In addition to the IAS, he was affiliated with the American Geographic Society, the American Institute of Architects, the Liturgical Arts Society, and the New York State Association of Architects.

## IAS News — News of Members

**Louis Achitoff** (M), formerly Vice-President of Operations for Flight Safety, Inc., has joined the Port of New York Authority as Supervisor, Airport Navigation Standards, Aviation Planning Division, Aviation Department.

**Gerald B. Brophy** (A), Vice-President and General Counsel of North American Aviation, Inc., has been named a Senior Vice-President of the firm.

**William M. Duke** (AF) has been appointed Director of the System Engineering Division, Space Technology Laboratories, Inc., Los Angeles, Calif. He was elected a Vice-President in April, 1958.

**Capt. Henry J. Dunn, Jr.** (A), Production Engineer with the Air Force Jupiter Liaison Office at the Army Ballistic Missile Agency, received the Air Force Commendation Medal for meritorious service. The citation stated that "Captain Dunn distinguished himself. . .by resolving complicated aeronautical engineering problems of the F-84F and SA-16 type aircraft. He conducted in-service engineering on the F-84 aircraft. . .expanded the MOAMA engineering services and was engineering advisor to the Department of Defense Standardization Group."

**Dr. Evan Evans** (A), Executive Director of the National Education Council, has been awarded the 1958 Frank G. Brewer Trophy by the National Aeronautic Association for outstanding work in the field of aviation education.

**Charles J. Gallant** (AF) has moved up from Vice-President to Executive Vice-President of North American Aviation, Inc. Before his promotion, he was also General Manager of the Columbus Division which post he now gives up.

**William H. Lane** (M) has joined the Columbus Division, North American Aviation, Inc., as a Senior Aerodynamics Engineer (Research). He was formerly Research Associate and Instructor, Department of Aeronautical Engineering, Ohio State University, Columbus, Ohio.

**Charles A. Naegeli, Jr.,** (M), formerly Project Engineer, Flight Refueling, Inc., has become Chief Engineer, Propellant-Actuated Devices, in the Missile Products Division, Beckman & Whitley, Inc.

**Alfred Ritter** (AF), formerly Supervisor of Aerophysics at Armour Research Foundation, has joined Therm-Electric Meters Co., Inc., Ithaca, N.Y., as Vice-President and Director of Therm Advanced Research Division.

**Dr. Merit Scott** (AF) has joined the Applied Sciences Division of Fairchild Engine and Airplane Corp. as Scientific Advisor to the staff.

**John Francis Victory** (M), Assistant to the Administrator of the NASA, has been awarded the Wright Brothers Memorial Trophy "for significant public service of enduring value to aviation in the U.S." by the National Aeronautic Association.

**Laurence L. Waite** (AF), Vice-President—Engineering and Planning, North American Aviation, Inc., has been made a Senior Vice-President of the company.

## IAS News — Corporate Member News

• **AC Spark Plug,** Division of General Motors, has appointed Leo W. Tobin, Jr., Manager, AC-Milwaukee, and Algie A. Hendrix to the new position of Assistant Manager.

• **Aerojet-General Corp.** has begun a new venture in rocket propulsion by becoming U.S. sales agent for D. Napier & Sons, Ltd., of London. The first Napier Scorpion has been received, marking the beginning of in-stock availability of fully developed liquid propellant rocket power plants for aircraft.

• **Aeronca Manufacturing Corp.** and **Longren Aircraft Co., Inc.,** have announced plans for a merger of the two firms. Under the plan, Longren will be operated as a division of Aeronca with no change in personnel or management. . . In conjunction with Emerson Electric Manufacturing Co., St. Louis, Mo., Aeronca has formed an industrial team to complete development of a missile training target system. The team plans to participate jointly in a competition for a missile/target system under consideration for inclusion in the Army family of missiles.

• **Aeroproducts, Allison Division, General Motors Corp.,** has formed a new engineering department known as the Advanced Research and Development Group. Dan H. Jacobson, formerly Chief of Aerodynamics, heads the group as Chief Research and Design Engineer.

• **American Airlines, Inc.,** has elected Francis H. Burr to its Board of Directors, filling a vacancy caused by the retirement of John W. Farley. Also, Florian J. Stevens has been appointed to the newly created post of Director, Cargo Sales Service, and Capt. Fred J. Shaw has been made Director, Flight Administration.

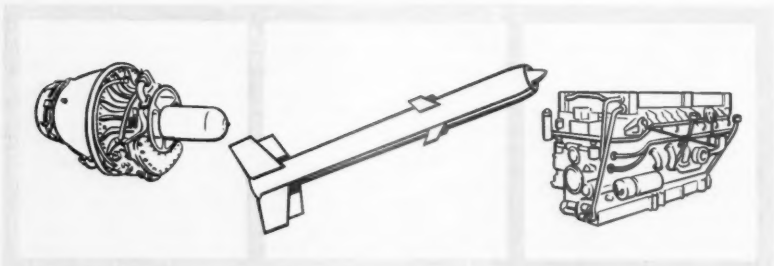
• **American Bosch Arma Corp.** has announced the appointment of John L. Taggart as Director of Marketing, with primary responsibilities in defense programs.

• **Avien, Inc.,** has named Robert C. Chilton as Controller-Administrative Manager.

• **Fairchild Engine and Airplane Corp.** has renamed its Guided Missiles Division, located at Wyandanch, L.I., N.Y., the Astrionics Division. The change in name was made to define more accurately the

# CAE POWER

- Research
- Development
- Production



TURBINE RAMJET RECIPROCATING

● Continental Aviation & Engineering Corp. is exceptionally well qualified, both by experience and by facilities, for work on the weapons systems of tomorrow. Our background embraces not only a half-century of internal combustion engine experience, but also years of pioneering in gas turbine engine development, and a full decade of work in the field of solid fuels for ramjet propulsion of missiles and target drones . . . Continental is staffed and equipped for a wide range of assignments, military and commercial. The Detroit Division Research and Development Department is supported by our modern-to-the-minute Component Testing Laboratory complete with environmental facilities located at Toledo. The Toledo Production Division now producing various turbine engines in volume is capable of supporting diversified programs . . . The CAE record of achievement is one of which many a larger company might be proud. Inquiries are invited from those having propulsion problems, on the ground, on the water, in the air.

☆ ☆ ☆

CONTINENTAL AVIATION & ENGINEERING CORPORATION

12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION


division's prime mission, which is the development and production of guidance and control (astrionics) systems and related electronic devices.

● **General Dynamics Corp.** . . . Stromberg-Carlson has named Dr. Donald G. Wilson General Manager of its San Diego Electronics Division.

● **General Precision Equipment Corp.** . . . General Precision Laboratory, Inc., has created two new groups within its Avionic Division. Commercial Avionic Sales, with Douglas Hembrough, Manager, will be responsible for the application and sale of GPL equipment; Commercial Avionic Engineering, with Lewis M. Lawton, Jr., Manager, will be responsible for planning and development of all GPL commercial avionic products. . . . Kearfott Co., Inc., has formed a Components Division as an autonomous operation devoted to the manufacture of servosystem components.

● **Grumman Aircraft Engineering Corp.** is building an avionics engineering laboratory at its Long Island facility. Construction was begun in December, 1958, and completion is expected by next fall. Total cost of the laboratory, including basic equipment, will be about $4 million. Also announced is the formation of a space projects "task force" to bring Grumman's top design engineers and research scientists together to study the wide range of problems connected with space and its exploration.

● **ITT Laboratories, a Division of International Telephone and Telegraph Corp.,** has appointed Harry Altman to the post of Executive Engineer. He now is responsible for the engineering administration of all programs, including those at installations throughout the country.

● **Walter Kidde & Co., Inc.,** . . . Aviation Division has opened a Sales Engineering Office in San Diego, Calif. J. L. Reddan, District Manager, will head the new office.

● **Lear, Inc.,** reports completion of plant expansions involving expenditures of over $2 million. The expansions represent a $172,000 sq. ft. program of construction at the Grand Rapids, Mich., Division; an addition of 2,844 sq. ft. to the Lear-Romec Division, Elyria, Ohio; and a 14,000 sq. ft. enlargement of the Astronics and LearCal Divisions, Santa Monica, Calif.

● **Minneapolis-Honeywell Regulator Co.** . . . Aeronautical Division has named R. O. Wolcott as Director of Administration. Mr. Wolcott retains his responsibilities as Chief Contracts Counsel and Assistant Secretary of Minneapolis-Honeywell.

● **North American Aviation, Inc.,** . . . Autonetics, in line with establishing a centralized research activity, has named Dr. Edgar L. Armi, Chief, Research Staff.

● **Northrop Aircraft, Inc.,** has elected Irving Roth Vice-President in Charge of Finance, and has named Charles C. Cilley to the new post of Corporate Treasurer and Comptroller.

● **Simmonds Aerocessories, Inc.,** has announced organization of a Specialty Valve Department, concentrating on design and manufacturing of mono- and

dual-propellant valves for use primarily in the aircraft and missile field.

• **Solar Aircraft Co.** is constructing a 60,000 sq. ft. engineering and research building and a huge furnace for heat treating and brazing missile components on its bayfront leasehold in San Diego, Calif. Construction of the furnace was begun in December, 1958; construction of the engineering building was scheduled to begin early this year.

• **Space Technology Laboratories, Inc.,** has appointed Dr. Ruben F. Mettler Executive Vice-President and General Manager. Jules Mersel has been named Manager of the Data Processing and Operations Department.

## IAS News — IAS Sections

### *Cleveland-Akron Section*

### Moeckel Addresses Members on Nonchemical Propulsion Means

**Wolfgang E. Moeckel** discussed "**Non-Chemical Propulsion Methods in Astronautics**" at the November meeting. Mr. Moeckel said that chemical and nonchemical propulsion systems might possibly be used, but that studies to date have indicated that, when large expeditions to outer space must be accomplished, the use of chemical methods would produce a system that would be too heavy; as a result, some forms of nonchemical propulsion system would have to be used. He also said that almost any expedition to space must be started from a vehicle in orbit, and that the vehicle perhaps would have to be assembled in orbit.

Mr. Moeckel went on to say that the components of the vehicle would have to be placed into orbit by a chemical means, and then grouped various nonchemical propulsion systems into three categories: (1) systems limited by material and temperature; (2) systems using magnetic containment of very high plasma; and (3) systems using electric or electromagnetic acceleration. These systems cover the use of solar batteries for use on satellite sustainers or APU's to nuclear turboelectric systems that could be used for manned flight to Mars. He said that high efficiencies and high reliability were important because a manned expedition to Mars and the return to earth would take several years.

Mr. Moeckel concluded by presenting a concept of a vehicle that might possibly be used for a manned expedition to Mars. The vehicle would be 600 ft. long, have a total gross weight of 322,000 lbs., contain a nuclear heat transfer propulsion system, and would require eight men and 88,000 lbs. of sustenance material. The round trip would take 1,100 days.

Preceding the meeting, members toured the Ohio Bell Telephone Co. facility at Akron. Dale Moon, representing Ohio Bell, gave the members some interesting statistics on the services rendered by Ohio Bell Telephone Co.

C. J. PENNIG, *Secretary*

### *Detroit Section*

### Plant Tour Held

**James DeRemer,** Chief Engineer, Toledo Division, Continental Aviation and Engineering Corp., outlined the purpose and activities of the Toledo Division to members who were guests of CAE at a November meeting. The meeting, organized by Sam Hunter, Training Director, Toledo Division, CAE, included a plant tour of the production, assembly, and test sections.

WILLIAM M. SPREITZER, *Secretary*

### *Hagerstown Section*

### Adhesive Bonding Discussed by 3 Fairchild Aircraft Speakers

**R. C. Smith,** Chief of Technical Engineering, Fairchild Aircraft and Missiles Division, was chairman of the November meeting program on "**Adhesive Bonding of Aircraft Structures.**" Three speakers discussed some of the problems of adhesive bonding, and the means of controlling the

Taber
TELEFLIGHT®
NEW MODEL 180
AIRBORNE PRESSURE TRANSDUCER
One of the first and most satisfactory of all Pressure Transducers, the Taber Teleflight has now been reengineered to a weight of LESS than 10 ozs. Its BONDED STRAIN GAGE construction makes it almost completely insensitive to vibration and shock. Its INFINITE RESOLUTION makes possible measurement of feather-light pressures. Can be used with Taber Indicator (shown below) or standard recorders and controllers to measure liquid or gaseous pressures. Handles extremely corrosive media, including fuming NITRIC ACID. Pressure ranges: 0 - 750 or 0 - 1,000 PSIA or PSIG with overload of 100%, Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature –65° F. to +250° F. (18° C to 121° C).
For ground testing, the Teledyne Models 176, 206 and 217 with pressure ranges from 0 - 100 up to 0 - 10,000 PSIG have long been favored by rocket and missile men.
WRITE FOR LITERATURE
TABER INSTRUMENT CORPORATION
Section 221 107 Goundry St., North Tonawanda, N. Y.
Telephone: LUdlow 8900 TWX - TON 277

## How Lockheed helps conserve defense dollars:

# The missile with 9 lives

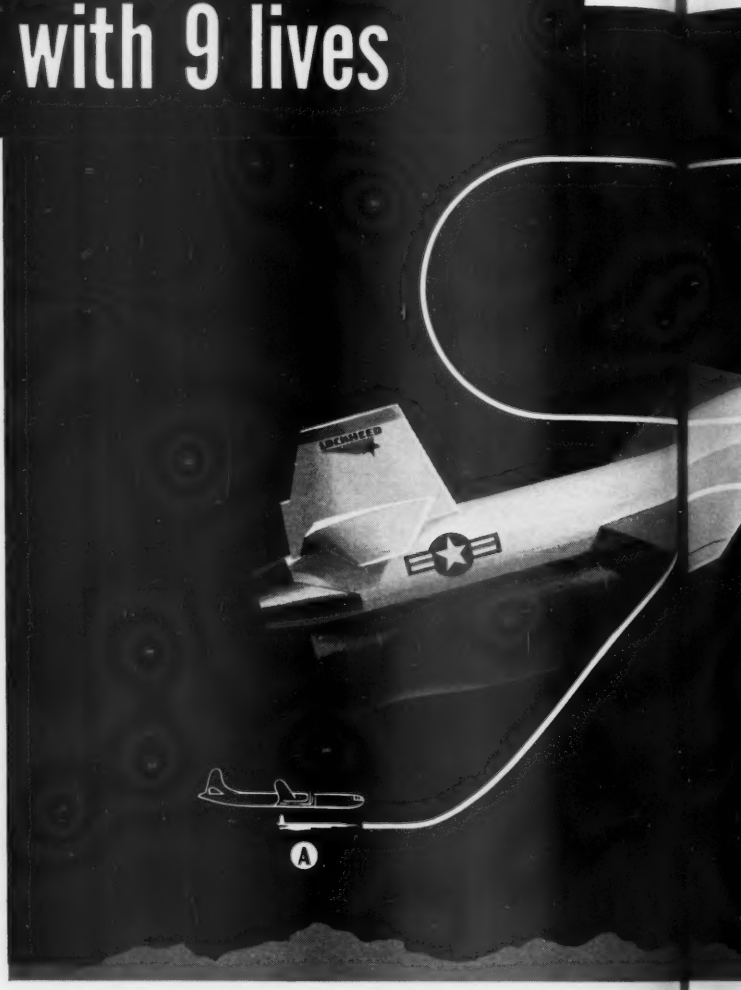
**The U.S. Army's** new Q-5 *Kingfisher* was designed by Lockheed's Missile Systems Division to provide our mighty arsenal of ground-to-air missiles with a realistic test of marksmanship—against high-altitude targets moving at supersonic speeds over 1500 miles-per-hour.

The *Kingfisher* is 38-feet long, 20-inches in diameter, has a 10-foot wingspan and weighs more than 7600 pounds. As it flashes across the skies it electronically simulates any desired size and type of "enemy" plane or air-breathing missile.

The *Kingfisher's* electronic Firing Error Indicator instantly and accurately tells ground controllers whether missiles fired at it are "hits" or "misses"—and automatically evaluates each missile's angle-of-attack, miss-distance, and other highly important technical data.

Undamaged by "hits" scored on its electronic image, the Q-5 *Kingfisher* is parachute recovered after each flight.

This Lockheed-developed "missile with 9 lives" will enable the U.S. Army to achieve hitherto impossible proficiency in missile marksmanship against supersonic targets—at a saving to taxpayers of approximately half a million dollars on each recovery flight.

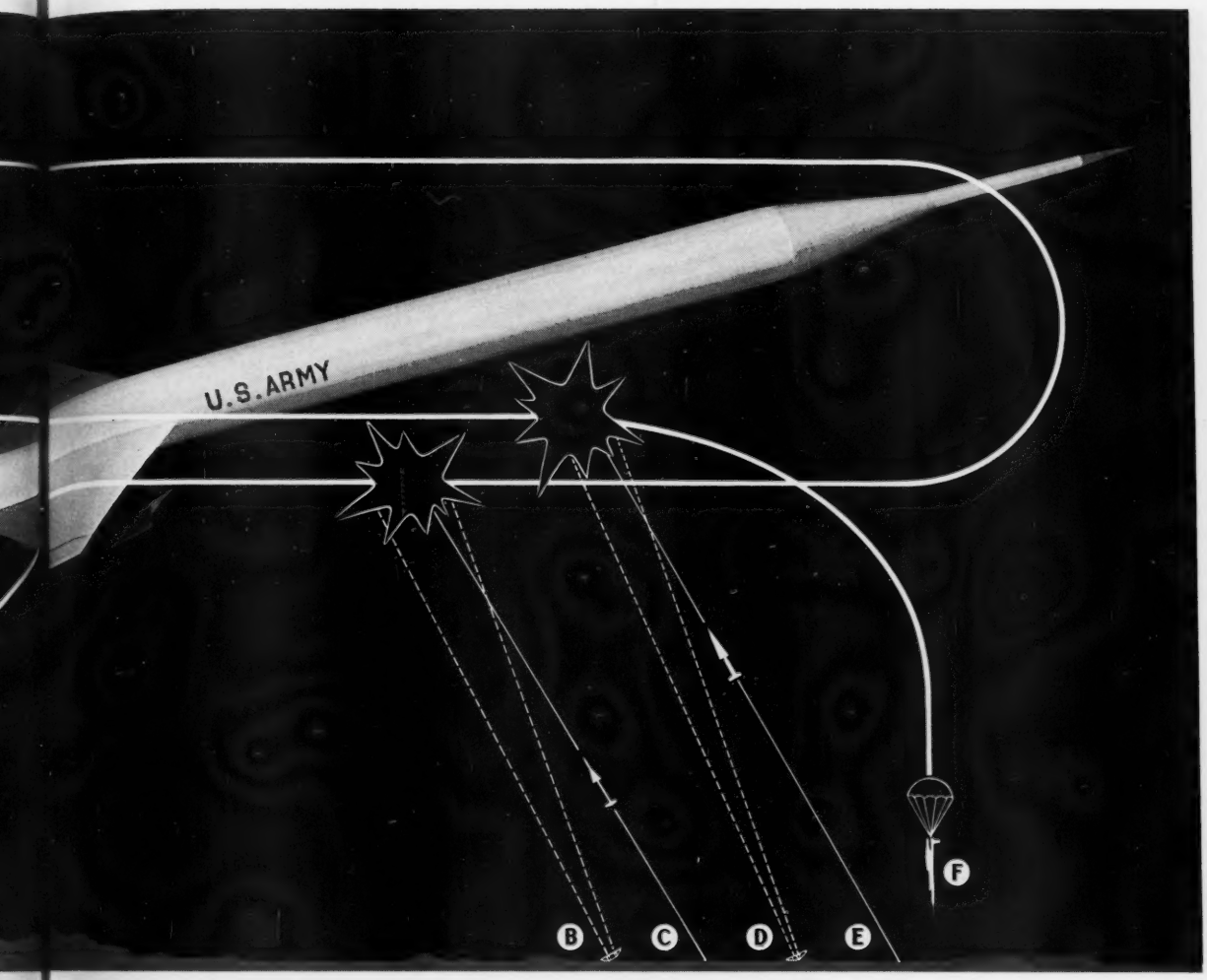



**Q-5 is dropped** by plane at 35,000 feet ((A) in diagram). Then its twin rockets ignite, propel it to speeds required to operate its ramjet engine.

**Q-5 is detected as "enemy"** by ground radar (B), and its speed, altitude, and course are fed into fire-control computer of Nike battery.

**Missiles fired at Q-5** are like those used in wartime—but lack high-explosive warheads. Nike missile (C) scores "hit" on Q-5's electronic image.

XUM



**Above: Entering oval flight pattern,** Q-5 attains speeds over 1500 mph. Second ground radar **(D)** and missile-launching battery **(E)** practice their marksmanship until Q-5 *Kingfisher's* fuel supply is exhausted.

**Left: Landing on its nose-spike** in a remote, uninhabited area, after floating down by parachute **(F)**, the Q-5 is recovered by U.S. Army ground crews—to be refueled and refitted for future flights.


# LOCKHEED

**LOCKHEED AIRCRAFT CORPORATION, MISSILE SYSTEMS DIVISION**

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT • ROCKETRY • ULTRASONIC AERODYNAMICS • SPACE INVESTIGATIONS • NUCLEAR PHYSICS • ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION • RAMJET PROPULSION TESTING

bonding processes to maintain the desired end result.

**E. L. Williams,** Project Stress Engineer on the SM-73 missile, discussed the sequence of events and the problems involved in obtaining an adequate and reliable bonding method on the structure of the SM-73. He said that a satisfactory bond must fill the gap between the mating surfaces, must be resistant to JP-4 fuel, and must make a satisfactory bond. It is expected that M-690 adhesive will be used soon. Heat and pressure are necessary to obtain a satisfactory bond. Mr. Williams also mentioned that the use of adhesives allows a smaller airframe than if riveted and built-up structure were used, because of the weight saving involved.

**D. E. Winter,** Tool Engineer, then discussed the use of adhesives on the F-27 and B-52 programs. He said that the bonding must be easy to apply, must be resistant to fuel and erosion, and must cure between room temperature and 350° F. Also mentioned was the fact that redux bonding is now generally used for the F-27's and B-52's, and that an autoclave is used for the pressure-heat process. Mr. Winter said that the surface preparation prior to bonding is very critical and should be very smooth. He concluded by showing slides of some of the tools, presses, etc., required in the process.

The final speaker, **D. Brengle,** Quality Control Materials Laboratory, discussed some of the measures required to maintain strict and adequate control over the finished product:

(1) To avoid damage, materials should be left in the containers in which they were shipped.

(2) Samples should be tested in the laboratory to be sure they meet the specifications, with tensile samples being machine-tested.

(3) Parts should be prefitted and chemically cleaned to assure a good bond.

Mr. Brengle added that process specimens be made during and prior to production in order to assure satisfactory final products, and that fluoroscopes and feeler gages be used to pick up imperfections, voids, and delaminations.

E. L. HARKLEROAD, *Secretary*

***Kansas City Section***

### Members, Students Join; Hear Talk on Space Travel

A joint meeting with the Student Branch at the University of Kansas was held November 18 on the campus at Lawrence, Kan., under sponsorship of the Student Branch and the chairmanship of Prof. Ammon S. Andes, head of the Aeronautical Engineering Department at the University.

**William H. Podolny,** Advanced Projects Staff Engineer, Pratt & Whitney Aircraft, addressed the group on **"Systems for Space Propulsion and Control."** The space travel problem was presented with a review of the technical barriers to be overcome; the present state of analytical development and hardware approaches currently being evaluated to meet this objective were examined. The address also contained a summary of the vehicle types and power generating systems for their propulsion, covering a spectrum of engines, including nuclear rockets, solar sails, solar reflectors, plasma jets, and ion propulsion.

After the talk, members were guided by Don Campbell, Analytical Engineer in Advanced Development, through a Pratt & Whitney display trailer which housed a cutaway model of the J-57 engine and a scale model of the Wilgoos Laboratory.

C. L. EDWARDS, *Secretary*

***Niagara Frontier Section***

### Fuels, Research Debated by Corp. Aide, Laboratory V-P

**Peter A. Stranges,** Associate Director, Energy Division, Olin Mathieson Chemical Corp., discussed **"Liquid High Energy Fuels for Aircraft and Missile Propulsion"** at the November meeting. He reviewed the program for liquid high energy fuels from its beginning in 1952 and discussed the composition and physical properties of the boron fuels, which consist of various borane compounds. He said that the heating value of these fuels yields a 30 to 40 per cent increase over the petroleum fuel ratings of about 18,500 B.t.u. per lb. Operationally, he said, the high energy fuels will be used mainly to extend the cruise capabilities of supersonic aircraft. Applications to turbojet, ramjet powered missiles, and liquid rocket systems were also discussed. Mr. Stranges mentioned that Olin Mathieson Corp., which developed the process, has constructed a facility for quantity production.

▶ **Dr. Alexander Flax,** Vice-President, Cornell Aeronautical Laboratory, at the October meeting discussed **"Research—Accomplishments, Problems, Prospects."** Dr. Flax said that the rapid economic and social development of the United States was tied directly to the pace of research and development activities. He explained that the increasing need for basic research is the result of the tightening of the development cycle from basic research to applied research, development, and, finally, production. He said that the value of random basic investigations is supported by historical facts, which show that most of the revolutionary basic concepts are discovered in undirected, independent studies. The importance of free interchange of information was stressed, and public appreciation of the aims and problems of research was described as the major factor in establishing a healthy atmosphere for the scientific community.

EDWARD Y. SING, *Secretary*

***San Antonio Section***

### Traffic Control, Safety Discussed

**Brig. Gen. Jerry D. Page,** Deputy Chief of Staff, Plans and Operations, Headquarters, Air Training Command, spoke at a late November meeting on **"Air Force View on Air Traffic Control and Air Safety."** He discussed in detail the problems as viewed by the Air Force, the factors affecting airspace saturation, and the tremendous growth of Instrument Flight Regulation traffic (ATRC centers handled traffic which increased from 150,000 in 1937 to 25,159,733 in 1958).

General Page then discussed the error factors, such as varying airspeed, altimeter errors, and terminal congestion. He also talked about the CAA statutory responsibilities and some of the actions taken by the Air Force to assist the CAA. He felt that one outstanding contribution by the Air Force Air Training Command was the pioneering work in the usage of reflective paint. Since the inception of this special paint, the General noted, mid-air collisions had shown a very definite decrease.

The meeting was held at the Randolph AFB Officers Club, and the members were welcomed by Col. W. K. Horrigan, Deputy Commander.

ROBERT R. PERRY, *Secretary*

***South Florida Section***

### Low Speaks on Stresses; J. D. Gill Elected Chairman

**"Method for Stress Analysis of Fuselage Cut-Outs"** was discussed by **Dr. Emmett Low, Jr.,** Professor of Mathematics, University of Miami, and formerly with the NACA, at the December meeting. He demonstrated by purely algebraic methods, that the frames, stringers, and skin adjacent to the cutout carry the additional stresses. Prof. Low, who participated in the early NACA project, said that numerous tables have been tabulated to give the percentage of stress distribution about the entire cyclindrical fuselage, and that the method is outlined in NACA Reports TN 3199, 3200, 3544, and 3460. He also discussed applications to aircraft fuselage modifications.

Election of officers followed, with Prof. John D. Gill elected Chairman; James Addison, Vice Chairman; Andrew C. McDermott, Secretary; and R. B. Phillips, Treasurer.

A. C. MCDERMOTT, *Secretary*

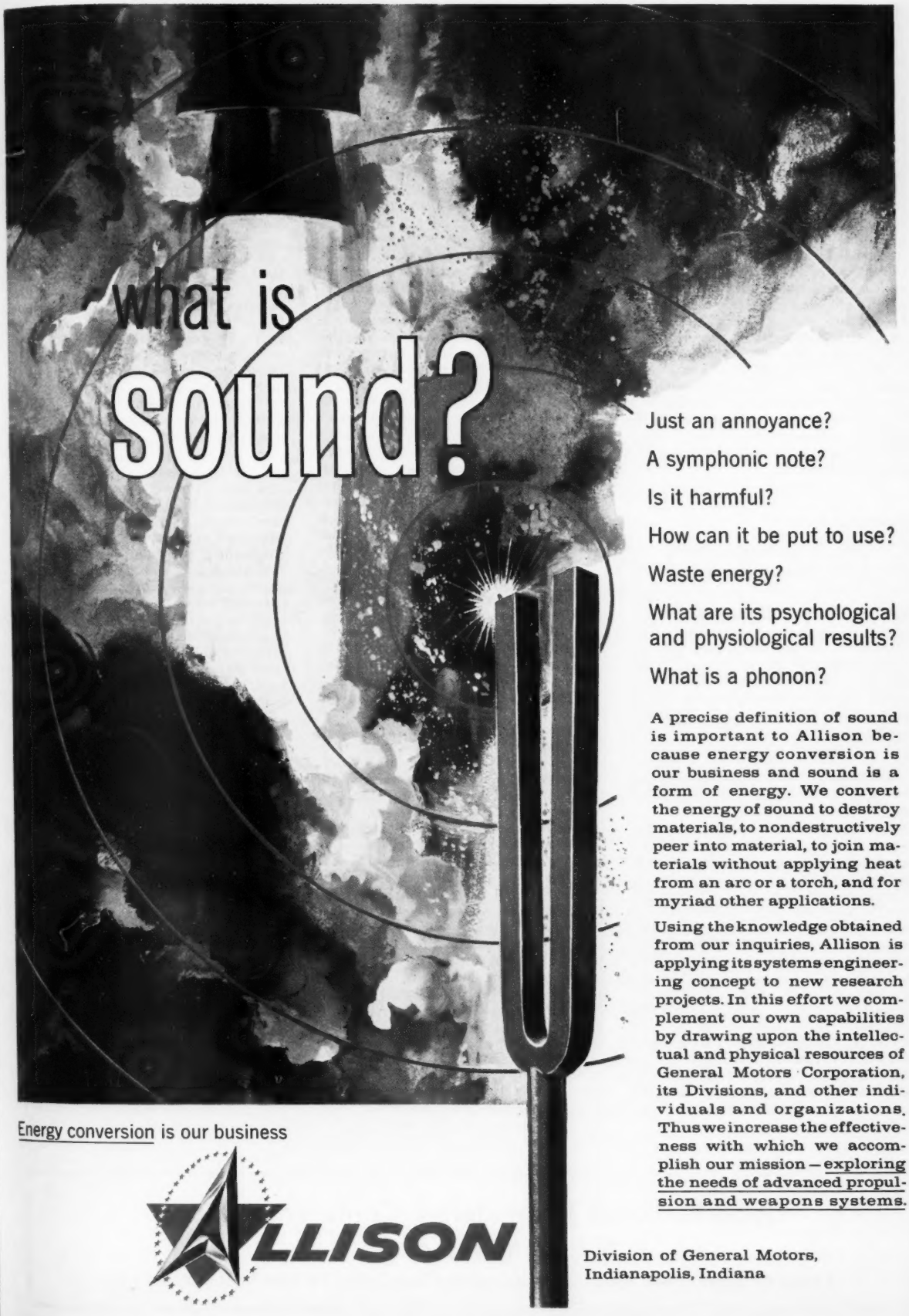
***Tulsa Section***

### Raspet Guest Speaker; Douglas Paper Presented

**Dr. August W. Raspet,** Head, Aerophysics Department, Mississippi State College, discussed **"A Simple Means for Solving Viscous Flow Problems"** at the November meeting.

Dr. Raspet explained how sailplane research can lead to a better understanding of aerodynamic phenomena and how this research has pointed the way to significant performance improvements. He presented data to show how, by the means of distributed suction and geometric modifications, the regions of laminar boundary layer were extended, and the attendant drag reduction obtained. Dr. Raspet said, he had found that the allotment of a small amount of power for distributed suction can give large increases in overall performance. He concluded with a discussion of his studies of bird flight.

▶ At the October meeting, a paper on **"Comparison of Two-Dimensional and Three-Dimensional Analyses of Earth-Moon Flight,"** written by **G. C. Goldbaum,**




Just an annoyance?

A symphonic note?

Is it harmful?

How can it be put to use?

Waste energy?

What are its psychological and physiological results?

What is a phonon?

A precise definition of sound is important to Allison because energy conversion is our business and sound is a form of energy. We convert the energy of sound to destroy materials, to nondestructively peer into material, to join materials without applying heat from an arc or a torch, and for myriad other applications.

Using the knowledge obtained from our inquiries, Allison is applying its systems engineering concept to new research projects. In this effort we complement our own capabilities by drawing upon the intellectual and physical resources of General Motors Corporation, its Divisions, and other individuals and organizations. Thus we increase the effectiveness with which we accomplish our mission — exploring the needs of advanced propulsion and weapons systems.

Energy conversion is our business

ALLISON

Division of General Motors,
Indianapolis, Indiana

Design Specialist, Missiles Aerodynamics, and **R. J. Gunkel,** Chief, Missiles Aerodynamics, both of Douglas Aircraft Co., Inc., and previously presented at the August meeting of the American Astronautical Society, was given by Allan M. McCaskill, Douglas Aircraft's Tulsa Division.

Results of considerations of an idealized two-dimensional system in which the earth and moon were considered to be isolated in space and to revolve in circles about their common center of mass were presented. The plane of the vehicle trajectory and the plane of the lunar orbit were also considered to be coincident. These were contrasted with results obtained from the analysis of a complete earth-moon-sun system, in which the motions of the bodies were in accordance with the ephemerides. In this case, the lunar orbit and vehicle trajectory planes were not coincident.

The comparison showed that general trends and approximate magnitudes of trajectory parameters and permissible errors can be established by simplified two-dimensional analyses. A more sophisticated analysis should be used for verification and for accurate determination of the launch parameters.

ALLAN M. MCCASKILL, *Secretary*

***Washington Section***

## Gell, Hetherington, Voas Heard on Aero/Space Medicine

At the November meeting, Honorary Chairman **Capt. C. F. Gell (MC), USN,** Special Assistant for Medical and Allied Sciences to the Assistant Chief for Research, Office of Naval Research; **Dr. Albert W. Hetherington,** Technical Director, Directorate of Life Sciences, Headquarters, Air Research and Development Command, USAF; and **Dr. R. B. Voas, USN,** assigned to NASA Space Projects, Langley Research Center, Va., discussed some of the major problems which must be solved in aero/space medicine before man can achieve space flight.

Captain Gell, who was awarded the John Jeffries Award in 1953, began with an account of an early experiment in which six men spent 7 days in a sealed chamber. The purpose of the experiment was to determine a specific value of the maximum oxygen gas pressure level that could be tolerated by a crew for use in designing an air recirculating system for a sealed chamber. It was known that men, when on 100 per cent oxygen for an extended period, developed a condition known as "oxygen poisoning." The chamber was kept at 10,000 ft., and an oxygen gas pressure $2^3/_4$ times normal sea level oxygen pressure was used. A continuous series of tests was run on the condition and performance of the "crew members" throughout the 7 day period. The "crew" members recorded each other's performance on the equipment used in the test with both still and motion pictures. The six men were kept completely incommunicado during the period of the test. The oxygen gas pressure level chosen for the test proved to be right at the tolerance level of the crew, and therefore a much more precise value of this tolerance level was established than had been known before.

Dr. Gell said that two other conclusions were established that should apply in the space age; first, a crew can maintain itself and perform well over a period of time in a confined sealed chamber, and, second, all that is needed for such a crew are healthy, well-trained, and well-motivated young men.

On the problems and requirements of predicting and assessing human response and performance in space environment, Dr. Hetherington said his discussion did not guarantee or even assume a useful level of human performance capability in space; his objective was to point out that a great deal of work could be done before actual manned satellite flight is attempted, both by means of preliminary human experimentation and by properly planned animal satellite experiments. The experiments should determine adequate means of instrumentation as well as define meaningful questions to be answered when the first manned satellite flights are attempted. However, many will be subjected to several conditions which will be difficult to duplicate accurately in preliminary testing, such as weightlessness and exposure to cosmic radiation. Animal experiments in space with mice, rats, and small and large primates can be used to explore the many possibilities of behavior which might occur.

Many different ways of observing and recording animal and human response may be used. Body function may be measured continuously, gross activity can be recorded in many ways, and predetermined response patterns can be observed. With a human crew two-way communication would be extremely valuable, as it has been in the work with high altitude balloon flights, and, finally, direct observation of the subject would be perhaps the most valuable assessment means of all. This could be accomplished in a manner similar to facsimile photo transmission, or sampled, stored, and occasionally transmitted television images, or, hopefully, live television. Combinations of the several methods of instrumentation will probably be used. One of the most promising of the new methods is the use of electrical indicators of physiological change, such as the present electrocardiograph, the electroencephalograph, the electromyograph, and the galvanic skin reflex.

In conclusion, Dr. Hetherington provided strong support for the requirement of direct observation of response and performance in experimental work by showing a film report of members of the Aero-Medical Laboratory of the WADC under short periods of weightlessness created by flying a C-131 on a zero *g* trajectory. For the few seconds the zero *g* condition could be established, the subject could perform quite well.

Next, Dr. R. B. Voas presented a review of the operational problems in telemetering physiological data from space vehicles, prepared by himself and Dr. N. L. Barr (MC) USN Director, Astronautics Division, USN Bureau of Medicine and Surgery. Dr. Voas began by proposing five operational criteria against which physiological measurements should be evaluated. They were: (1) the significance of the behavior measured; (2) the sensitivity of the measurement; (3) the reliability with which it can be measured; (4) the lack of interference with the pilot; and (5) the cost in weight, space, and power requirements.

Several biological measurements which can be telemetered were discussed, as were some of the problems which have been encountered in telemetering these measurements in monitoring the safety of hazardous experimental flights, such as stratospheric balloon ascents. One of the basic problems in setting meaningful limits for the physiological responses to be monitored is that normal conditions do not apply to response in a hazardous flight. It is quite difficult to set limits for these situations of stress. In testing the reactions of experienced pilots, it has been found that individual responses in stressful conditions vary widely. The lack of success in developing significant relationship between a pilot's reactions and his efficiency indicates that a much greater effort is required in this area to determine base lines for interpreting physiological data received during experimental tests.

Dr. Voas concluded with a Navy film report of equipment developed under Dr. Barr's direction to measure air crew physiological performance and associated communication equipment to transmit for remote analysis the data observed over available communication channels anywhere in the world.

A social period preceded the program under the sponsorship of the Hughes Aircraft Co., represented by Paul J. Larsen, Manager, Hughes East Coast Operations, and Gordon Murphy, Assistant Manager. Dr. Ludwig Lederer, Medical Director, Capital Airlines, and President-Elect of Aero-Medical Association, was honorary guest for the evening.

QUENTIN J. GOSS, *Secretary*


**1958 National Telemetering Conference Report**

**Price—$4.00**

**Special Publications Dept., Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.**

# Hughes in Southern California

# announces the establishment of

# a major new division . . .

# the COMMUNICATIONS DIVISION

The growing importance of global and space communications, together with major contributions of the Hughes Communications Laboratory, such as the Long Arm and Quicksilver programs, has resulted in the creation of the COMMUNICATIONS DIVISION of the Hughes Aircraft Company. The new division is fully integrated and will be responsible for communications research, development, manufacturing and sales. Expansion plans are ambitious and aggressive, and the backlog of contracts already awarded promises an expansion consistent with the spectacular records established by the other major divisions of Hughes Aircraft Company.

The establishment of Hughes as a major factor in the communications industry has created many openings for experienced electronic engineers in the following areas:

*Senior Staff Engineers*
*RF Power Design*
*Digital Data Processing*
*Transistor Circuit Design*
*Communication Systems Analysis*
*Propagation Specialists*
*Upper Atmosphere Physicists*

also

*Airborne Equipment Productizing Engineers*
*Test Engineers*

For further information write Mr. John Melville at the address below.

**HUGHES**

COMMUNICATIONS DIVISION, P. O. Box 90-902, Los Angeles 45

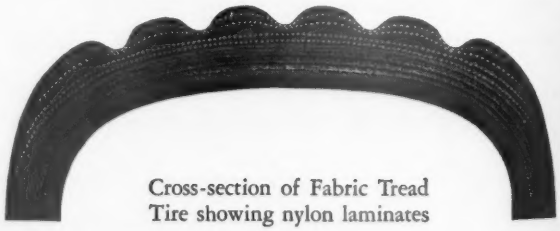
# B. F. Goodrich Fabric Tread Tires picked for the X-15

Up, up — 100 miles up at fantastic speeds — the North American X-15 will carry man to the fringe of Earth's atmosphere. And when the X-15 lands it will land at a speed that will demand top tire performance.

That's why B.F.Goodrich Fabric Tread Tires have been selected for the nose wheels of the X-15. Already in service on our fastest jet fighters and missiles, these revolutionary B. F. Goodrich tires outperform all previous jet tires.

Nylon laminates built into tread stock reduce rubber distortion under load, equalize modulus between tread and carcass, check formation of "shock wave". Unique Fabric Tread designs eliminate stress points found in ordinary high-speed tires, also resist tread cutting and punctures.

Without a doubt, B.F.Goodrich Fabric Tread Tires mean safer takeoffs, more landings, for your supersonic aircraft. Find out more about Fabric Tread right now by contacting *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. AS-29, Akron, Ohio.*



Cross-section of Fabric Tread Tire showing nylon laminates

**B.F.Goodrich *aviation products***

# AERO/SPACE Reviews

*. . . current literature of aeronautical engineering and space technology*

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering worldwide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command

A list of the principal periodicals received in the IAS Library is published annually in the January issue.

The AERO/SPACE ENGINEERING INDEX, formerly the AERONAUTICAL ENGINEERING INDEX published since 1947, provides an annual cumulation of the materials reviewed in this section.

### THE IAS LIBRARY

Publications reviewed in this section are maintained by the Library for use by the IAS Membership. They are *not* for sale but are made available through the facilities of the Library.

LENDING SERVICES: Institute members, both Individual and Corporate, may borrow periodicals, reports, and books for a period of 2 weeks, excluding time in transit. Excepted are certain reference books and those IAS publications that may be purchased.

PHOTOCOPY SERVICES: The Library is equipped to provide, as a service, positive photocopies of certain materials in its collections. Rates on request.

For detailed information about these and other services, write to:

*John J. Glennon, Librarian*
*Institute of the*
*Aeronautical Sciences, Inc.*
*2 East 64th Street*
*New York 21, New York*


PERIODICALS AND REPORTS..... 74
INTERNATIONAL AERONAUTICAL ABSTRACTS. 95
BOOKS ..... 117


## Subject Index to Periodicals & Reports


Acoustics, Sound, Noise..... 74
Aerodynamics, Fluid Mechanics
Aerothermodynamics..... 74
Boundary Layer..... 74
Control Surfaces..... 74
Fans..... 74
Flow of Fluids..... 74
Internal Flow..... 74
Jet Flaps & Wings..... 76
Stability & Control..... 76
Wings & Airfoils..... 76
Aeroelasticity..... 76
Air Transportation..... 76
Airplanes
Air Conditioning, Pressurization... 76
Control Systems, Automatic Pilots.. 76
Description..... 76
Ejection Seats..... 76
Fuel Tanks..... 76
Landing, Landing Loads..... 77
Operating Characteristics, Economics..... 77
Airports..... 77
Aviation & Space Medicine..... 77
Chemistry..... 78
Computers..... 78
Control Theory..... 78
Education & Training..... 79
Electronics..... 79
Amplifiers..... 79
Antennas, Radomes..... 79
Circuits & Components..... 80
Communications..... 80
Construction Techniques..... 80
Cooling..... 80
Delay Lines..... 80
Dielectrics..... 80
Magnetic Devices..... 80
Network, Filters..... 80
Noise, Interference..... 80
Piezoelectricity..... 80
Power Supplies..... 80
Radar..... 80
Reliability..... 80
Resistors..... 80
Semiconductors..... 80
Telemetry..... 82
Transmission Lines..... 82
Wave Propagation..... 82
Wave Theory..... 82
Equipment..... 82
Electric..... 82
Hydraulic & Pneumatic..... 82
Fuels & Lubricants..... 82
Instruments..... 82
Flight Instruments..... 82
Flow Measuring Devices..... 82
Gyroscopes..... 82
Panels & Dials..... 85
Pressure Measuring Devices..... 85
Recording Equipment..... 85
Temperature Measuring Devices... 85
Vibration Measuring Devices..... 85
Machine Elements
Bearings..... 85
Fastenings..... 85
Gears & Cams..... 85
Rotating Discs & Shafts..... 85
Materials..... 85
Ceramics & Ceramals..... 85
Corrosion & Protective Coatings... 85
High Temperature..... 86
Metals & Alloys..... 86
Metals & Alloys, Nonferrous..... 86
Nonmetallic Materials..... 86
Testing Methods..... 86
Mathematics..... 86
Mechanics..... 88
Meteorology..... 88
Missiles, Rockets..... 88
Navigation..... 88
Nuclear Energy..... 90
Parachutes..... 90
Photography..... 90
Physics..... 90
Power Plants..... 90
Jet & Turbine..... 90
Reciprocating..... 92
Rocket..... 92
Production..... 92
Metalworking..... 92
Nonmetalworking..... 92
Production Engineering..... 92
Tooling..... 92
Propellers..... 92
Research, Research Facilities..... 92
Flight Testing..... 111
Rocket Sleds, Tracks..... 111
Wind Tunnels..... 111
Rotating Wing Aircraft, Helicopters. 111
Safety..... 111
Space Travel..... 111
Structures..... 113
Bars & Rods..... 113
Beams & Columns..... 113
Connections..... 113
Cylinders & Shells..... 113
Elasticity & Plasticity..... 113
Fatigue..... 113
Plates..... 113
Plates with Holes..... 114
Rings..... 114
Sandwich Construction..... 114
Testing Methods..... 114
Thermal Stress..... 115
Wings..... 115
Thermodynamics..... 115
Combustion..... 115
Heat Transfer..... 115
VTOL & STOL..... 120
Water-Based Aircraft..... 120

## Acoustics, Sound, Noise

**Noise Origin, Power, and Spectra of Ducted Centrifugal Fans.** F. S. Howes and R. R. Real. *ASA J.*, Aug., 1958, pp. 714–720. 14 refs.

**Reflection from a Fluid of Higher Sound Velocity.** J. C. Savage. *ASA J.*, Oct., 1958, pp. 974–978. Application of the method of Cagniard to obtain an exact solution for the pressure response to a spherically symmetric acoustic pulse originating at a source within a semi-infinite fluid bounded below by a fluid of higher sound velocity. The solution is expressed in terms of elliptic integrals.

**O Pogloshchenii Zvuka Konechnoi Amplitudy v Relaksiruiushchei Srede.** A. L. Poliakova. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 51–53. In Russian. Study on the absorption of sound of finite amplitude in relaxation media.

**Rasprostranenie Razryvov v Zvukovykh Volnakh.** K. E. Gubkin. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 561–564. In Russian. Presentation of a solution for the equations of gas dynamics describing the propagation of low-amplitude waves applied to the case of acoustic waves.

**Jet Noise Reduction by Induced Flow.** Ira Dyer, P. A. Franken, and P. J. Westervelt. *ASA J.*, Aug., 1958, pp. 761–764. 10 refs. Analysis of the effect on the generation of jet noise by the secondary air induction of a modified jet nozzle. It is shown that the combination of secondary air with primary jet air creates a new jet stream of larger area, lower velocity, and lower noise generation.

**An Investigation of Some Phenomena Relating to Aural Detection of Airplanes.** H. H. Hubbard and D. J. Maglieri. *U.S., NACA TN 4337*, Sept., 1958. 49 pp. 11 refs. Presentation of test results indicating the significance of such factors as the external noise-level characteristics of the aircraft, the propagation phenomena relating to the conditions of the problem, and the ambient or background noise conditions at the location.

**Strength Distribution of Noise Sources Along a Jet.** H. S. Ribner. (*UTIA Rep. 51*, Apr., 1958.) *ASA J.*, Sept., 1958, p. 876.

**Experimental Comparison Between Noise from Unheated Subsonic Air Jets Having 4:1 Elliptic and Circular Orifices.** Alan Powell. *ASA J.*, July, 1958, pp. 642, 643.

**The Quietness of the Comet.** F. B. Greatrex. *de Havilland Gazette*, June, 1958, pp. 96, 97. Evaluation of the effectiveness of jet-noise suppressors developed by Rolls-Royce.

**Noise Reduction in Air Force Control Towers.** R. J. Christman. *USAF RADC TR 58-123 [AD 202092]*, Oct., 1958. 41 pp. 17 refs.

**Torques Due to Acoustical Radiation Pressure.** G. Maidanik. *ASA J.*, July, 1958, pp. 620–623. USAF-supported derivation of a general expression for the torque on an object using an approach similar to that used by Westervelt to derive the general expression for the force. The general expression is then specialized to plane waves incident in an arbitrary direction.

## Aerodynamics, Fluid Mechanics

### *Aerothermodynamics*

**Transient Temperature and Thermal Stresses in Skin of Hypersonic Vehicle with Variable Boundary Conditions.** Shin-Yuan Chen. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–9.*) *ASME Trans.*, Oct., 1958, pp. 1,389–1,394. 10 refs. Analysis that introduces the concept of exponential functions of time to represent the coefficient of heat transfer and adiabatic wall temperature. Application is made to the case of a finite slab where one boundary has a variable heat-transfer coefficient and a variable adiabatic wall temperature while the other boundary is insulated.

**On the Stable Shape of an Ablating Graphite Body.** Daphne Christensen and R. D. Buhler. *J. Aero/Space Sci.*, Jan., 1959, p. 54. Test results showing that graphite rods ablate to sharply pointed, cone-like shapes rather than to blunt-nosed bodies.

### *Boundary Layer*

**Hypersonic Flow About a Thin Body of Revolution.** R. Timman. (*NATO AGARD 11th Wind-Tunnel & Model-Testing Panel, Scheveningen, July 8-12, 1957.*) *NATO AGARD Rep. 141*, July, 1957. 10 pp. Derivation of boundary-layer equations for a thin body of revolution taking into account the curvature of the body. A similar solution is found and the application of a Pohlhausen method with a suitable simple velocity profile gives the effect of the radius of curvature in general terms.

**On the Plateau and Peak Pressure of Regions of Pure Laminar and Fully Turbulent Separation in Two-Dimensional Supersonic Flow.** W. J. Guman. *J. Aero/Space Sci.*, Jan., 1959, p. 56.

**Note on the Shock-Induced Unsteady Laminar Boundary Layer on a Semi-Infinite Flat Plate.** S. H. Lam and L. Crocco. *J. Aero/Space Sci.*, Jan., 1959, pp. 54–56. Iterative solution of the boundary layer assuming constant Prandtl Number and viscosity.

**On the Solution of the Laminar Boundary-Layer Equations.** Melvin Epstein. *J. Aero/Space Sci.*, Jan., 1959, pp. 58, 59.

**Possible Similarity Solutions of the Laminar, Incompressible, Boundary-Layer Equations.** A. G. Hansen. (*ASME Annual Meeting, New York, Dec. 1-6, 1957, Paper 57–A–79.*) *ASME Trans.*, Oct., 1958, pp. 1,553–1,559; Discussion, pp. 1,559–1,562. 20 refs. Review of research on the problem of obtaining similarity solutions of three-dimensional boundary-layer equations.

### *Control Surfaces*

**The Oscillating Inboard Flap at Supersonic Speeds.** E. F. Tyler. *J. Aero/Space Sci.*, Jan., 1959, pp. 56–58. Calculation of the lift and moment for the flap, as well as the hinge moment.

### *Fans*

**Ducted Fan Design Theory.** C. G. Van Niekerk. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58–A–4.*) *J. Appl. Mech.*, Sept., 1958, pp. 325–331. Presentation of a theory by which it is possible to design ducted fans directly and without having to choose any parameters in an arbitrary fashion.

### *Flow of Fluids*

**The Definitions of Terms Relating to Various Flow Regimes of a Gas—Some Proposals.** Appendix—**Summary of Proposed Definitions.** C. H. E. Warren and A. D. Young. (*Gt. Brit., ARC CP 368*, 1958.) *RAeS J.*, Nov., 1958, pp. 801–804.

**A Note on Conical Flow.** E. C. Kennedy. *J. Aero/Space Sci.*, Jan., 1959, pp. 59, 60. Discussion of the different effects on calculations in using the values of the specific heat ratio of 1.4 and 1.405.

**Ob Odnom Tochnom Reshenii Uravneniia Energii v Chastnom Sluchae Dvizheniia Viazkoi Neszhimaemoi Zhidkosti.** G. A. Tirskii. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 555–560. In Russian. Derivation of an exact solution of energy equations for the specific case covering the motion of a viscous incompressible liquid.

**Gas Parameters at the Critical Point with Variation of the Specific Heat Taken Into Account.** Iu. P. Lun'kin. *Sov. Phys.-Tech. Phys.*, Aug., 1957, pp. 1,700–1,704. Translation. Analysis showing that the temperature and pressure dependence of the specific heat of a gas leads to a significant increase in the density and a drop in the stagnation temperature, while the pressure change remains insignificant. The coefficient of resistance has a characteristic maximum related to excitation of molecular oscillations.

**Drag Unit for the Artificial Generation of Turbulent Shear Flow.** H. G. Elrod. *Rev. Sci. Instr.*, Sept., 1958, pp. 762–764. Description of a device to generate turbulent flows of a prescribed time-mean velocity distribution.

**On the Effect of Flow Separation on the Lift of Slender Bodies.** Svetopolk Pivko. *RAeS J.*, Nov., 1958, pp. 832, 833.

**Sverkhzvukovoe Obtekanie Operennykh i Neoperennykh Tonkikh Tel Vrashcheniia.** P. I. Zheludev. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 74–82. In Russian. Investigation of the supersonic flow around finned bodies of revolution and derivation of a solution, up to the second approximation, for the case of flow around arbitrary bodies of revolution.

**O Dvizhenii Rombovidnogo Profilia so Skorost'iu, ne Prevyshaiushchei Skorost' Zvuka.** S. K. Aslanov. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 452–464. 20 refs. In Russian. Derivation of an approximate solution, based on previously obtained exact equations and using the method of generalization of incompressible flow, for the case of compressible transonic flow around a finite diamond-shaped profile.

**Theoretical Pressure Distribution on a Hemisphere-Cylinder Combination.** Anthony Casaccio. *J. Aero/Space Sci.*, Jan., 1959, pp. 63, 64. USAF-supported analysis.

**Motion of Rigid and Fluid Spheres in Stationary and Moving Liquids Inside Cylindrical Tubes.** W. L. Haberman and R. M. Sayre. *U.S., Navy Dept., David Taylor Model Basin, Rep. 1143*, Oct., 1958. 66 pp. 30 refs. Analysis based on Stoke's approximation for the hydrodynamic equations for slow flow; thus, inertia terms can be neglected, and the stream function satisfies a fourth-order differential equation similar in form to the biharmonic one.

**Zadacha o Dvizhenii Ideal'noi Neszhimaemoi Zhidkosti Okolo Polubeskonechnoi Plastiny s Uchetom Vikhrevogo Otryva.** M. D. Ustinov. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 120–123. In Russian. Study covering the problem of motion of an ideal incompressible liquid around a semi-infinite plate, taking into account the vortex separation.

**Ob Uchete Skol'zheniia pri Obtekanii Polubeskonechnoi Ploskoi Plastiny Potokom Viazkogo Gaza.** V. P. Shidlovskii. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 83–90. In Russian. Derivation of a solution for the case of viscous flow around a semi-infinite flat plate, taking into account the effect of slip.

**Udar Reshetki Plastin pri Simmetrichnom Kavitatsionnom Obtekanii.** S. I. Parkhomovskii. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 565–568. In Russian. Study covering the case of a plate moving in an ideal fluid bounded by parallel walls, and analysis of the generated shock phenomena.

**Rearrangement of the Temperature Field in Flow Around a Bend.** E. R. G. Eckert and T. F. Irvine, Jr. (*ASME Gas Turbine Power Conf., Wash., Mar. 2–6, 1958, Paper 58–GTP–2.*) *ASME Trans.*, Nov., 1958, pp. 1,765–1,772. Presentation of measurements of the temperature and velocity field for a specific duct geometry which bends the flow by 90° and simultaneously accelerates it to an average exit velocity which is twice the inlet velocity.

**Invarianty Odnorodnoi i Izotropnoi Turbulentnosti v Szhimaemoi Viazkoi Zhidkosti.** K. A. Sitnikov. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 29–32. In Russian. Analysis covering the invariants of homogeneous and isotropic turbulence in a compressible viscous fluid.

**A Lagrangian Formulation of the Boltzmann-Vlasov Equation for Plasmas.** F. E. Low. *Royal Soc. (London) Proc., Ser. A*, Nov. 11, 1958, pp. 282–287. Development of a variational principle for the Boltzmann-Vlasov equation for an ionized gas in an electromagnetic field.

**O Volnakh Rimana v Magnitnoi Gidrodinamike.** A. G. Kulikovskii. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 987–990. In Russian. Study of Riemann waves in magnetohydrodynamics for the case of arbitrary field distribution, in relation to the wave front, leading to new mechanical effects.

**Magneto-Hydrodynamic Oscillations of a Perfectly Conducting Fluid Sphere Placed in a Uniform Magnetic Field.** Tsuneji Rikitake. *Phys. Soc. Japan J.*, Oct., 1958, pp. 1,224–1,230. Derivation of rigorous expressions for zonal oscillations and approximations for two fundamental normal modes of oscillation.

**Study of the Transverse Motion of Ions in a Discharge in a Strong Longitudinal Magnetic Field.** A. Zharinov. *Sov. Phys.-Tech. Phys.*, Aug., 1957, pp. 1,675–1,682. Translation. Analysis showing that the establishment of the overall nature of the transverse motion of ions is made possible by a plane rotating probe. The ion energy acquired in the radial electric fields of a discharge is evaluated.

**On Flow of Electrically Conducting Fluids Over a Flat Plate in the Presence of a Transverse Magnetic Field.** V. J. Rossow. *U.S., NACA Rep. 1358*, 1958. 20 pp. 42 refs. Supt. of Doc., Wash., $0.25.

**Theory of the Flow of a Gas in a Porous Material in the Near-Knudsen Region.** B. V. Deriagin and S. P. Bakanov. *Sov. Phys.-Tech. Phys.*, Sept., 1957, pp. 1,904–1,918. Translation.

**Asymmetry of the Concentration Front During Miscible Displacement in Porous Media.** A. E. Scheidegger and V. C. Larson. *Can. J. Phys.*, Nov., 1958, pp. 1,476–1,482.

**O Tochnykh Resheniiakh Uravnenii Odnomernoi Gazodinamiki s Udarnymi i Detonatsionnymi Volnami.** I. S. Shikin. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 33–36. In Russian. Derivation of exact solutions for the equations of one-dimensional gas dynamics covering the case of shock and detonation waves.

**Ob Uravneniiakh Dvizheniia Razrezhennogo Gaza.** M. N. Kogan. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 425–432. In Russian. Generalization of the Boltzmann equation of motion for rarefied gases.

**The Effect of Slip on Induced Pressures.** J. A. Laurmann. *J. Aero/Space Sci.*, Jan., 1959, pp. 53, 54. Presentation of results from a slip analysis made of the zero pressure gradient boundary-layer flow, using a Pohlhausen type solution, combined with the Stewartson transformation to give the compressibility effect.

**On Two-Dimensional Vortex Motion in a Simply Connected Region.** B. J. Andersson. *KTH Trans. 126*, 1958. 6 pp.

**Vikhrevoi Sled pri Obtekanii Kolebliushchikhsia Tsilindrov.** M. A. Pavlikhina and L. P. Smirnov. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 124–127. In Russian. Experimental investigation covering the mechanism of the vortex observed in the wake of a cylinder oscillating in a flow of gas or liquid.

### *Internal Flow*

**The Boundary Layer on the End Wall of a Turbine Nozzle Cascade.** Appendix I—**Variation of Vorticity Configuration Through a Converging Channel.** Appendix II—**Evaluation of Friction Force from Observed Velocity Distribution at a Distance from Wall.** Yasutoshi Senoo. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–172.*) *ASME Trans.*, Nov., 1958, pp. 1,711–1,720. 14 refs. Comparison of the observed boundary layer behavior with the predicted flow by a three-dimensional laminar boundary-layer theory.

**The Effect of Wakes on the Transient Pressure and Velocity Distributions in Turbomachines.**

# MAN'S FIRST SPACE COMMUNICATION STATION

On 12 October 1958, an historic event took place. A group of Space Technology Laboratories' engineers at Cape Canaveral, Florida, transmitted radio signals far out into space to the NASA/Air Force Pioneer space probe vehicle. The tiny receiver and transmitter in the Pioneer relayed these same signals to the Space Technology Laboratories' group at Manchester University, England. • This significant experiment promises, like those earlier achievements of Morse, Bell, and Marconi, to pave the way for the use of space vehicles to relay information to and from points on earth. One day the entire world will view televised events as they happen. • Future experiments of this kind will undoubtedly assist mankind in his search to understand, use, and benefit from his knowledge of space phenomena. • Scientists and engineers whose interests and abilities enable them to contribute to these developments are invited to join our technical staff.

**Space Technology Laboratories, Inc.** P. O. BOX 95001, LOS ANGELES 45, CALIFORNIA

The 250′ radio telescope pictured here is operated by a team of British scientists under the direction of Professor A. C. B. Lovell, University of Manchester, whose cooperation contributed materially to making this achievement possible.

R. X. Meyer. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–83.*) *ASME Trans.*, Oct., 1958, pp. 1,544–1,552. ONR-supported analysis of the interaction between blade rows that results in transient fluctuation in pressure distributions for the case of two-dimensional incompressible flow through lightly loaded cascades.

**Annular Flow—A Note on the Turbulent Velocity Profile.** Henry Barrow. *RAeS J.*, Nov., 1958, pp. 830, 831. Brief review of the important characteristics of the turbulent velocity profile of a plain concentric annulus and some methods of correlating the velocity distribution. The average velocities in an annular section are examined, and some experimental data are correlated by a modified power law.

**Nekotorye Tochnye Resheniia Zadachi o Techenii Gaza v Trube s Uchetom Treniia i Konvektivnogo Teploobmena.** G. L. Grodzovskii. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 127–129. In Russian. Evaluation of a class of exact solutions for the problem of a plane stationary gas flow, taking into account the effect of friction and convective heat transfer.

**O Techenii Gaza v Tsilindricheskoi Trube pri Nalichii Treniia i Teploobmena.** I. I. Mezhirov. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 118–120. In Russian. Presentation of certain exact solutions and a method for the quantitative calculation of basic equations in the problem of gas flow in cylindrical pipes, taking into account friction and heat transfer.

**Three-Dimensional Laminar Boundary Layer in Curved Channel with Acceleration.** Yasutoshi Senoo. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–173.*) *ASME Trans.*, Nov., 1958, pp. 1,721–1,729; Discussion, pp. 1,729–1,733. 17 refs. Development of a theory for two families of three-dimensional boundary layers. A turbine nozzle cascade is approximated by a pair of logarithmic spirals and the observed boundary layer behavior compared with the prediction of the theory.

**Supersonic Aspiration.** A. R. Weyl. *Aeronautics*, Nov., 1958, pp. 38–41. 16 refs. Review of the design of air intakes and diffusers and the direct generation of electric energy from nuclear reactions.

**Thrust of a Supersonic Conical Nozzle with Non-Isentropic Flow.** P. N. Rowe. *Chartered Mech. Engr.*, June 1958, pp. 255, 256. Abridged.

**Numerische Darstellung von ebenen und rotationssymmetrischen transsonischen Düsenströmungen mit gekrümmtem Schalldurchgang.** E. Martensen and K. von Sengbusch. *Max-Planck-Inst. Strömungsforsch. Mitteil. No. 19*, 1958. 117 pp. DM 11. In German. Numerical representation of plane and rotationally symmetrical transonic nozzle flows with curved transition of the sonic region.

**A Theoretical Evaluation of the Coanda Nozzle.** Kuo-Tai Yen. *Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5501*, July 5, 1955. 29 pp. Investigation of the Coanda effect as applied to a two-dimensional nozzle with a bend attached to one side of its exit. The obtained results are discussed.

**A Note on the Effect of Surface Finish on the Thrust of a Supersonic Conical Nozzle.** P. N. Rowe. *RAeS J.*, Nov., 1958, p. 829.

**Flow in a Jet Directed Normal to the Wind.** R. Jordinson. *Gt. Brit., ARC R&M 3074* (Oct., 1956) 1958. 17 pp. BIS, New York, $1.17. Experimental investigation of the flow in an air jet, ejected normal to an air stream from an orifice in a plane floor, for several values of the ratio of wind velocity to jet exit velocity. The path of the jet and the shape of its cross section are determined.

**Calcul de la Transmission de Chaleur dans la Couche Limite Turbulente de Tuyères Supersoniques et Hypersoniques.** Jérôme Persh. (*A. E. R. A. Internatl. Congr. Rockets & Guided Missiles, Paris, Dec. 3–8, 1956.*) *Fusées*, July, 1958, pp. 86–96. In French. Calculation of heat transfer in the turbulent boundary layer of supersonic and hypersonic nozzles. Theoretical results agree with those obtained experimentally at Mach Numbers between 5 and 10.

**O Techeniiakh v Okrestnosti Poverkhnosti Perekhoda v Soplakh Lavalia.** O. S. Ryzhov. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 433–443. In Russian. Study, based on previously obtained results, covering certain properties of axisymmetric flows for the case of Laval nozzles.

### *Jet Flaps & Wings*

**Some Simple Results for Two-Dimensional Jet-Flap Aerofoils.** D. A. Spence. *Aero. Quart.*, Nov., 1959, pp. 395–406. Study indicating that the lift coefficient and the pressure distribution of a thin two-dimensional wing at zero incidence can be obtained directly when the jet momentum coefficient $C_j$ is small.

### *Stability & Control*

**The Recovery of an Aeroplane from a High Speed Dive.** A. D. Young and S. Neumark. *Aircraft Eng.*, Nov., 1958, pp. 332–341. Step by step calculation of the recovery with fixed elevator from a high-speed dive for three different aircraft. Three different approximate methods for calculating the recovery after the initial oscillatory phase are developed.

### *Wings & Airfoils*

**Numerical Aspects of Unsteady Lifting-Surface Theory at Supersonic Speeds.** H. C. Garner. *Gt. Brit., ARC CP 398* (May, 1957) 1958. 6 pp. 18 refs. BIS, New York, $0.24. Brief discussion of the general problems in computing the unsteady aerodynamic loading on finite wings in a supersonic stream when the plan form, Mach Number, mode, and frequency of oscillations are given.

**Ordinates and Theoretical Pressure-Distribution Data for NACA 6- and 6A-Series Airfoil Sections with Thicknesses from 2 to 21 and from 2 to 15 Percent Chord, Respectively.** E. W. Patterson and A. L. Braslow. *U.S., NACA TN 4322*, Sept., 1958. 99 pp.

**An Experimental Investigation of Leading-Edge Flow Separation from a 4 per cent Thick Two-Dimensional Biconvex Aerofoil.** B. D. Henshall and R. F. Cash. *Gt. Brit., ARC R&M 3091* (Feb., 1957) 1958. 17 pp. BIS, New York, $1.17.

**Wing Flow Measurements of the Damping in Pitch Derivative of a 45° Delta Wing-Body Combination and with a Tailplane in Two Positions.** R. Rose. *Gt. Brit., ARC CP 402* (Aug., 1957) 1958. 13 pp. BIS, New York, $0.45.

## Aeroelasticity

**Ostsilliatsionnye Svoistva Form Ravnovesiia Sterzhnia pri Prodol'nom Izgibe.** A. S. Kondrat'ev. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 541–543. In Russian. Study covering stability of a bar in the case of transverse deformation in order to determine the oscillating properties.

**Nekotorye Voprosy Ustoichivosti Obolochek v Bol'shom.** I. I. Vorovich. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 37–40. 12 refs. In Russian. Analysis of the basic equations in the nonlinear theory of shells used to study the stability of shells.

**Kolebaniia Tonkogo Poliplana Tandem v Ploskom Neszhimaemom Potoke.** M. D. Khaskind. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 465–472. In Russian. Study of small vibrations of a thin tandem polyplane in plane incompressible flow.

**Remarks on "Analytical Results of Certain Nonlinear Flutter Problems."** D. S. Woolston and R. E. Andrews. *J. Aero/Space Sci.*, Jan., 1959, pp. 51–53. Presentation of an analog approach to determine the magnitude of the disturbance required to induce flutter.

**A Discussion of the Flutter of Submerged Hydrofoils.** H. N. Abramson and Wen-Hwa Chu. *Southwest Res. Inst. Dept. Eng. Mech. TR 1*, Aug. 15, 1958. 33 pp. 17 refs. Study of the available data relating to flutter in high-density fluid media. A comparison of theory and experiment is made showing that certain serious discrepancies exist, and a number of possible reasons for such discrepancies are discussed in detail.

**Effect of the Free Surface on the Flutter of Submerged Hydrofoils.** Wen-Hwa Chu and H. N. Abramson. *Southwest Res. Inst. Dept. Eng. Mech. TR 3*, Sept. 12, 1958. 29 pp. Derivation of expressions for the unsteady lift and moment acting on an oscillating hydrofoil submerged under a free surface.

**A Comparison of Theoretical and Experimental Loads on the B-47 Resulting from Discrete Vertical Gusts.** Ch. E. Jackson and J. E. Wherry. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 784.*) *J. Aero/Space Sci.*, Jan., 1959, pp. 33–45. 11 refs.

**Experimental Model Techniques and Equipment for Flutter Investigations; A Survey of British Practice.** W. G. Molyneux. *Aircraft Eng.*, Nov., 1958, pp. 324–330. 12 refs.

**On the Transverse Vibrations of Rectangular Orthotropic Plates.** N. J. Huffington, Jr., and W. H. Hoppmann, II. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–85.*) *J. Appl. Mech.*, Sept., 1958, pp. 389–395. 16 refs. Derivation of frequency equations and modal eigenfunctions for the flexural vibrations of rectangular plates of orthotropic material.

**Coupled Vibrations of Thin-Walled Beams of Open Cross Section.** J. M. Gere and Y. K. Lin. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–26.*) *J. Appl. Mech.*, Sept., 1958, pp. 373–378. Determination of coupled frequencies of free vibration for beams with various end conditions, including simple supports, fixed ends, and cantilever.

**The Calculation of Optimum Concentrated Damping for Continuous Systems.** R. Plunkett. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–93.*) *J. Appl. Mech.*, June, 1958, pp. 219–224. Presentation of a method for damping calculation and application to four cases. Specific results and general conclusions are given.

**Exact Analysis of the Plane-Strain Vibrations of Thick-Walled Hollow Cylinders.** D. C. Gazis. *ASA J.*, Aug., 1958, pp. 786–794. 13 refs. Integrated study of the vibration phenomena in the framework of the linear theory of elasticity. Approximate expressions for the frequencies of free modes are derived for moderately thick shells.

## Air Transportation

**Special Issue: Airlines of the World.** *The Aeroplane*, Nov. 7, 1958, pp. 681–702. *Partial Contents:* The Changing Pattern of Air Transport; World Airline Statistics—1957. Guide to the World's Airlines.

**Tomorrow's Transports and Their Ground Equipment.** *Aeronautics*, Aug., 1958, pp. 42–44.

**Special Issue: Air Shippers' Manual.** *Air Transp.*, Nov., 1958, pp. 3–90. Detailed directory to cargo airlines, cargo statistics, and other information related to air freight.

**The Soviet Role in International Civil Aviation.** Hans Heymann, Jr. *J. Air Law & Commerce*, Summer, 1958, pp. 265–280. Discussion of new Russian air transport equipment and projected air routes in international air traffic. The political aims of this new expansion are also evaluated.

## Airplanes

### *Air Conditioning, Pressurization*

**The Air Conditioning System of the DC-8.** A. A. Hershfield. *SAE J.*, Oct., 1958, pp. 32–34. Abridged. Includes details on freon system for cooling, controls, and distribution system.

### *Control Systems, Automatic Pilots*

**Piloted Flight Control Systems.** L. W. Strobel. *SAE J.*, Nov., 1958, pp. 93–96. Survey of problems due to increasing performance requirements of modern aircraft, and evaluation of future trends and concepts in the development of flight control systems.

**A Case of Longitudinal Stick-Free Dynamic Instability of an Aircraft Fitted with Power-Operated Control, g-Restrictor and Spring Feel. Appendix I—Evaluation of the Stick Force per g. Appendix II—The Effect of Neglecting the Power-Unit Transfer Function.** S. Neumark, J. Collingbourne, and H. H. B. M. Thomas. *Gt. Brit., ARC R&M 3094* (July, 1954) 1958. 43 pp. 14 refs. BIS, New York, $2.70.

**Designing a Pitch g-Limiter for Delta Fighters.** Howard Stern. *Space/Aeronautics*, Dec., 1958, pp. 54–59.

**Synchronizing Wing Flap Cylinders.** E. C. Fox. *Appl. Hydraulics & Pneumatics*, Oct., 1958, pp. 116–118. Description of hydro-mechanical systems used to synchronize the flaps on the Short S. B. 5. experimental aircraft.

### *Description*

**Three-Way Guide to British Aircraft.** *Aeronautics*, Sept., 1958, p. 78.

**The Comet: Planned for Maintenance.** *de Havilland Gazette*, Aug., 1958, pp. 120–122. Discussion of some design changes and improvements incorporated in the Comet 4 to ease maintenance.

**Avro Arrow Design.** *The Aeroplane*, Oct. 10, 1958, pp. 566–568. Discussion of the development and design characteristics of the all-weather fighter.

**The Disk-Type Aircraft.** L. G. Cramp. *Aeronautics*, Dec., 1958, p. 84–91 (ff.). Presentation of a disc-type aircraft design incorporating a lightweight structure. Inherent advantages are outlined and discussed.

### *Ejection Seats*

**Selection and Design of Escape Capsules.** D. M. Root. *SAE J.*, Nov., 1958, pp. 46–50. Analysis of the problems involved in selecting and designing an escape capsule for supersonic aircraft.

**New Open Ejection Seats.** A. I. Beck and George Hildebrand. *SAE J.*, Oct., 1958, pp. 67–69. Abridged. Description of the development of escape systems for a wide range of airplane speeds and altitudes. Accomplishments in fulfilling the essential design requirements, such as ejection acceleration and separation, dynamic stability, deceleration and windblast, and landing and post landing condition, are also presented.

### *Fuel Tanks*

**Definitions to be Used in the Description and Analysis of Drag; Report of the Definitions Panel. Appendix—Definitions of Certain Terms Used in the Description and Analysis of Drag.** (*Gt. Brit., ARC CP 369*, 1958.) *RAeS J.*, Nov., 1958, pp. 796–801.

**DC-8 Fuel System Independent of Auxiliary Power.** M. A. O'Connor and W. B. King. *SAE J.*, Nov., 1958, pp. 32–35. Abridged. Includes details of the fuel feed system, fuel filter, and refueling, fuel dump, and vent systems.

**Ring Damping of Free Surface Oscillations in a Circular Tank.** J. W. Miles. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–31.*) *J. Appl. Mech.*, June, 1958, pp. 274–276.

Analysis of the effect of an annular ring on the sloshing oscillations of liquid in a cylindrical tank.

**Liquid Propellant Inertia and Damping Due to Airframe Roll.** Herbert Reismann. *Jet Propulsion*, Nov., 1958, pp. 746, 747. Analysis to determine the degree of propellant participation in the rolling motion of an airframe. It is shown that the rolling motion is dependent on frequency and that the higher the frequency, the lower the effective propellant moment of inertia. Damping is shown to increase with rolling frequency.

**On the Sloshing of Liquid in a Flexible Tank.** J. W. Miles. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-12.*) *J. Appl. Mech.*, June, 1958, pp. 277–283. Derivation of the kinetic and potential energies of an incompressible fluid having a free surface in a cylindrical tank subjected to translation, rotation, and simple bending. The results are illustrated by a calculation of the frequency equation for coupled bending and free-surface motions.

### *Landing, Landing Loads*

**Low Tire Friction and Cornering Forces on a Wet Surface.** E. N. Harrin. *U.S., NACA TN 4406*, Sept., 1958. 27 pp.

### *Operating Characteristics, Economics*

**C-123J Performance Tests. Appendix I—Data Analysis Methods. Appendix II—General Aircraft Information.** Ch. E. Kroll and R. E. Williams. *USAF FTC TR 58-31 [AD 152304]*, Oct. 5, 1958. 87 pp.

**Comparing Aircraft Engines by Mission Requirements and Aircraft Performance.** E. W. Beans. *Aero/Space Engrg.*, Jan., 1959, pp. 32–36. Performance comparison using the parameter termed the engine factor which is the ratio of the engine thrust to the weight of the propulsion system and the payload. The comparison of the engines is made on a basis of the summation of the engine factors for each flight parameter at the required mission range.

**Complexity and Progress in Transport Aircraft.** N. E. Rowe. (*RAeS Weybridge Branch, 6th R. K. Pierson Memorial Lecture, Oct. 30, 1957.*) *RAeS J.*, Nov., 1958, pp. 787–795. 11 refs. Discussion of the overall advance in efficiency of the transport aircraft, the contributions made by various design parameters, and the effects of such developments. Operating costs, rates, and range of air transport are considered.

## Airports

**Special Issue: Airports and Their Equipment.** *Flight*, Nov. 7, 1958, pp. 721–742. *Partial Contents:* Development of London Airport; Planning for the New Era, G. W. Stallibrass. Focus on Turn-Round, J. W. R. Taylor. Where Do They Come from? Big Jets and Concrete. International Airports Facts and Figures.

## Aviation & Space Medicine

**The Aeromedical Realities of Space Travel.** M. S. White. (*3rd Europ. Congr. Av. Med. Louvain, Sept. 23, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 707–715. 14 refs. Brief history of space travel and discussion of the contributions of aviation medicine to space exploration.

**Space Cabin Design.** A. M. Mayo. (*AAS 4th Annual Meeting, New York, Jan. 31, 1958, Preprint 57–30.*) *J. Astron. Sci.*, Spring, 1958, pp. 11–14. Discussion of space cabin design, including the problems of internal environment, ecology, meteors, and space debris.

**Altitude Exposure and Intra-Aortic Infusion of Noradrenalin in the Dog.** Gordon Vawter and H. H. Wayne. *USAF SAM Rep. 58–30*, Feb., 1958. 8 pp.

**The Effect of Exposure to Simulated High Altitudes on Anaphylaxis in Mice.** W. E. Harris and J. D. Fulton. *USAF SAM Rep. 58–42*, Jan., 1958. 5 pp. 10 refs.

**The Effect of Hypoxia on Tolerance to Positive Acceleration.** B. F. Burgess, Jr. *J. Av. Med.*, Oct., 1958, pp. 754–757. Experimental investigation showing that low oxygen partial pressures cause a decreased tolerance to acceleration stress.

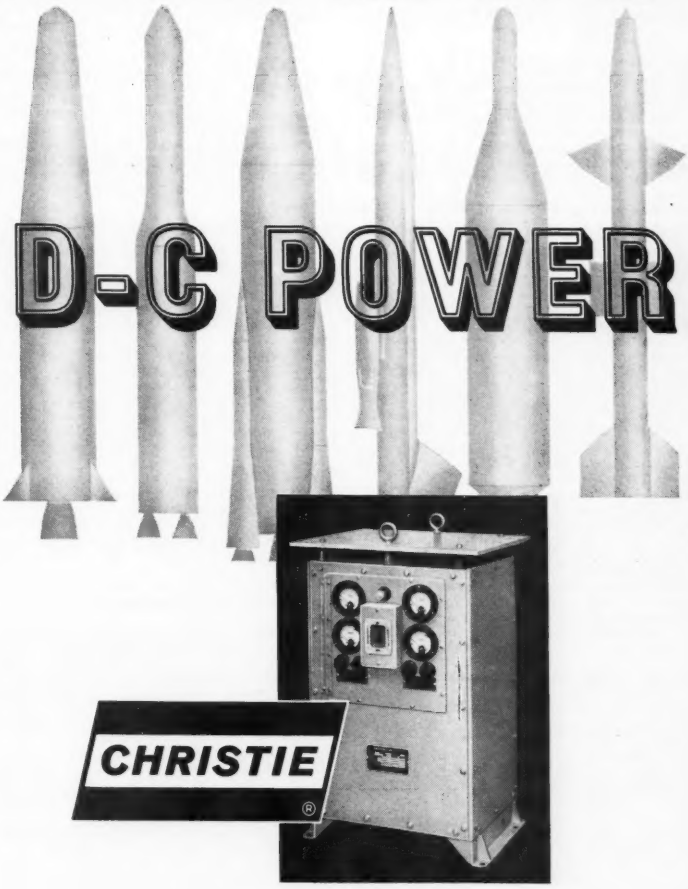
**The Spatial Vectorcardiogram During Acceleration.** Stuart Bondurant and W. A. Finney. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 26, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 758–762. Investigation of the effects of positive, negative, and transverse acceleration patterns.

**Multidirectional *g*-Protection in Space Vehicles.** H. J. Von Beckh. (*8th Internatl. Astron. Congr., Barcelona, Oct. 6–12, 1957.*) *Brit. Interpl. Soc. J.*, Sept.-Oct., 1958, pp. 525–533. 34 refs. Description of the anti-*g* ejection capsule and of its function in flight and during escape. The relevant literature is reviewed.

**Transthoracic Pressure in Man During Rapid Decompression.** U. C. Luft and R. W. Bancroft. *USAF SAM Rep. 56–61*, Aug., 1956. 13 pp. Study of pressures recorded in the human chest during rapid decompression under controlled conditions in a low-pressure chamber.

**Dysbarism: Grade IV Chamber Reactions or Instances of Neurocirculatory Collapse Occurring**


THOR TITAN ATLAS BOMARC POLARIS TALOS



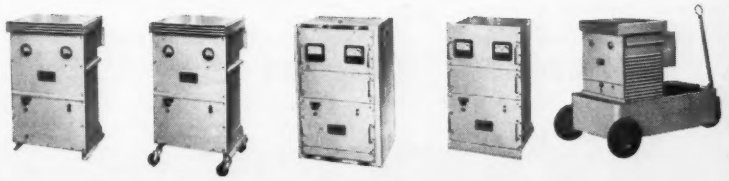

**THERE IS A REASON**...why *CHRISTIE* was selected as the principal source of D-C Power Supplies for all the above projects... **RELIABILITY**

CHRISTIE'S rigid Quality Control is approved by the A.E.C. and leading Aircraft and Missile Manufacturers.

***CHRISTIE ELECTRIC CORP.***

3410 W. 67th St., Los Angeles 43, Calif., Dept. AE

Precisely regulated Power Supplies of permanent stability. Ratings up to 1500 amperes. Bulletin on Standard Militarized units available on request.



**in the U. S. Air Force, 1950–1955.** (*Aero Med. 28th Annual Meeting, Denver, May 8, 1957.*) *USAF SAM Rep. 58–85*, June, 1958. 17 pp. 15 refs.

**Investigation of the Fatigue in Man.** *Milan U., Lab. Physiol. Final Rep.* (*AFOSR TR 58–117*) [*AD 202359*], 1958. 8 pp.

**Cumulative Auditory Fatigue.** J. F. Jerger. *USAF SAM Rep. 58–46*, Mar., 1958. 9 pp. Study of the cumulative effects of repeated fatigue-producing stimuli on threshold recovery time, explored as a function of the intensity of the fatiguing stimulus in 26 normal ears.

**The Ionic Thermocouple Theory of the Mechanism of Thermal Sensibility.** C. M. Williams. *USAF SAM Rep. 58–53*, Mar., 1958. 16 pp. 40 refs.

**Basic Research in the Field of Vision. I—On the Variability of the Electrical Response of the Human Eye to Stimuli of Different Color.** Marcella Bittini and Ivan Nicoletti. **II—Electroretinographic Research on the Parameters Which Define the Efficiency of a Light Stimulus.** L. R. Rositani and Ivan Nicoletti. *Inst. Naz. Ottica TN 2* (*AFOSR TN 58–408*) [*AD 158212*], Apr., 1958. 16 pp. 11 refs.

**Message Repetition and Receiver Confirmation of Messages in Noise.** E. C. Carterette. *ASA J.*, Sept., 1958, pp. 846–855. USAF-supported study.

**Binaural Effects in Remote Masking.** I. J. Hirsh and Michel Burgeat. *ASA J.*, Sept., 1958, pp. 827–832. USAF-supported research.

**Intensive Determinants of Remote Masking.** R. C. Bilger. *ASA J.*, Sept., 1958, pp. 817–824. USAF-supported research.

**Intensity and Duration of Noise Exposure and Temporary Threshold Shifts.** Walter Spieth and W. J. Trittipoe. *ASA J.*, Aug., 1958, pp. 710–713. USAF-sponsored research.

**Advantages of the Discriminability Criterion for a Loudness Scale.** W. R. Garner. *ASA J.*, Nov., 1958, pp. 1,005–1,012. 18 refs. ONR-supported research.

**Maintenance of Alertness by a Loud Auditory Signal.** Irwin Pollack and P. R. Knaff. *ASA J.*, Nov., 1958, pp. 1,013–1,016. USAF-supported study.

**Detection of Multiple Component Signals in Noise.** D. M. Green. *ASA J.*, Oct., 1958, pp. 904–911. USAF-Army-supported study.

**Signal Detection as a Function of Frequency Ensemble. I.** F. A. Veniar. *ASA J.*, Nov., 1958, pp. 1,020–1,024. Army-sponsored research.

**Prolonged After-Effect of Centripetal and Tangential Accelerations on Cerebellar Potentials.** *Milan U., Lab. Physiol. Final Rep.* (*AFOSR TR 58-37*) [*AD 152246*], 1958. 5 pp.

**Behavioral Effects of Whole Body Vibration.** M. M. Mozell and D. C. White. (*Aero. Med. Assoc. 29th Annual Meeting, Wash., Mar. 25, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 716–724. Experimental study of the effect of whole body vibration on the ability to read digits of an airplane mileage indicator and on tracking ability.

**Impact Thresholds of Brain Concussion.** A. G. Gross. *J. Av. Med.*, Oct., 1958, pp. 725–732. ONR-supported analysis of the resonance-cavitation theory of brain concussion evaluating the various physical factors relating to the impact thresholds of brain concussion. Instrumentation techniques to obtain threshold acceleration data are developed.

**Relation of Injury to Forces and Direction of Deceleration in Aircraft Accidents.** H. G. Moseley and A. F. Zeller. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 25, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 739–749. Review of aircraft accidents that occurred over a two-year period to determine the path followed by such aircraft during actual crashes, and to relate this to variations in aircraft attitude and injury to occupants.

*7* **Physiologic Considerations in Design for High-Speed, High-Altitude Flight.** J. W. Raeke. *SAE J.*, Aug., 1958, pp. 52–55. Evaluation of several human limitations of importance for the design of high-altitude vehicles, including oxygen and pressure requirements, acceleration, and cosmic radiation.

**Changes in Cochlear Endolymphatic Oxygen Availability, Action Potential, and Microphonics During and Following Asphyxia, Hypoxia, and Exposure to Loud Sounds.** G. A. Misrahy, E. W. Shinabarger, and J. E. Arnold. *ASA J.*, Aug., 1958, pp. 701–704. 21 refs. USAF-supported research.

**Harmonic Distortion in Cochlear Models.** Juergen Tonndorf. *ASA J.*, Oct., 1958, pp. 929–937. 15 refs. USAF-supported research.

**Vertebral Fractures in Survivors of Military Aircraft Accidents.** S. E. Neely and R. H. Shannon. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 750–753.

**Prediction of Speech Intelligibility at High Noise Levels.** J. M. Pickett and Irwin Pollack. *ASA J.*, Oct., 1958, pp. 955–963. 10 refs. USAF-supported study.

**Residual Effects of Low Noise Levels on the Temporary Threshold Shift.** W. J. Trittipoe. *ASA J.*, Nov., 1958, pp. 1,017–1,019. USAF-supported research.

**Design of an Algal Culture Chamber Adaptable to Space Ship Cabin.** J. G. Gaume. *USAF SAM Rep. 58–61*, May, 1958. 3 pp.

**Effects of Hyperventilation on Speech and Hearing.** H. C. Robinson. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 25, 1958.*) *J. Av. Med.*, Oct., 1958, pp. 763–768. 12 refs. Investigation showing that hyperventilation results in a significant increase in speech intelligibility and in no change in the auditory threshold for a 4,000 cps tone.

**Respiratory Compensation to Metabolic Alkalosis in Dogs; Influence of High Oxygen Concentration.** J. L. Reeves and E. B. Brown, Jr. *USAF SAM Rep. 58–99*, June, 1958. 7 pp. 13 refs.

**Some Persisting Effects of Nuclear Radiation Exposure on the Behavior of the Rhesus Monkey.** A. A. McDowell and W. L. Brown. *USAF SAM Rep. 58–63*, Apr., 1958. 3 pp.

**Latent Effects of Chronic Whole-Body Irradiation of Monkeys with Mixed Source Radiation.** R. T. Davis, C. B. Elam, and A. A. McDowell. *USAF SAM Rep. 57–59*, Feb., 1958. 31 pp. 21 refs.

**A Comparison of Normal and Irradiated Monkeys on an Oddity-Reversal Problem.** A. A. McDowell and W. L. Brown. *USAF SAM Rep. 58–73*, Apr., 1958. 4 pp. 12 refs.

**Latent Effects of Chronic Whole-Body Irradiation on the Performance of Monkeys on the Spatial Delayed-Response Problem.** A. A. McDowell and W. L. Brown. *USAF SAM Rep. 58–50*, Apr., 1958. 3 pp.

**Iron-59 Metabolism as an Index of Hematopoietic Damage and Recovery in Monkeys Exposed to Nuclear Radiation.** Q. L. Hartwig, G. S. Melville, Jr., T. P. Leffingwell, and R. J. Young. *USAF SAM Rep. 58–59*, Mar., 1958. 6 pp. 16 refs.

## Chemistry

**Kinetics of the Sulphuration of Metallic Surfaces. I—Surface Reaction of Copper and Platinum with Thiourea. II—The Surface Reaction of Copper with Sodium Polysulphide Solutions. III—The Surface Reaction of Copper with Benzene Solutions of Sulphur.** J. Llopis, J. M. Gamboa, and L. Arizmendi. *Inst. Quim. Fis. AR 1* (*AFOSR TN 58-639*) [*AD 162170*], May, 1958. 52 pp. 89 refs.

**Electrochemical Behavior of Polycrystalline and Single Crystal Lead.** Guido Poli. *Milan Polytech. LEPCM TN 12* (*AFOSR TN 58–238*) [*AD 154140*], Dec., 1957. 15 pp. 10 refs.

**Chemical Kinetics by Nuclear Magnetic Resonance.** O. E. Myers. *Convair Sci. Res. Lab. RR 3*, June 15, 1958. 63 pp. 31 refs. Description of magnetic resonance phenomena and derivation of the Bloch equations as modified by chemical reactions. The determination of chemical lifetimes from line-shape measurements, using phase detection, is treated mathematically.

**Research on Anodic and Cathodic Behavior of Metals.** Roberto Piontelli. *Milan Polytech. LEPCM Final Rep.* (*AFOSR TR 58–97*) [*AD 162165*], May, 1958. 27 pp. 40 refs.

**The Source of the Nitrogen Impurity in Electrodeposited Chromium.** N. Ryan and E. J. Lumley. *Australia, ARL Rep. Met. 30*, Aug., 1958. 14 pp.

**Explosive Reaction of Diborane in Dry and Water-Saturated Air.** E. L. Poling and H. P. Simons. *Ind. & Eng. Chem.*, Nov., 1958, pp. 1,695–1,698.

**Explosive Reactions of Diborane in Benzene-Saturated Air.** P. E. Sample and H. P. Simons. *Ind. & Eng. Chem.*, Nov., 1958, pp. 1,699–1,702. 14 refs.

**Rates of Selected Reactions Involving Nitrogen and Oxygen.** Norman Davidson. *Avco Res. Lab. RR 32*, June, 1958. 13 pp. 24 refs. USAF-sponsored research.

**The Polymerisation of Phosphonitrilic Chlorides. IV—Some Aspects of the Bulk Polymerisation of the Trimer.** F. G. R. Gimblett. *Gt. Brit., RAE TN Chem. 1331*, June, 1958. 12 pp.

**Density Studies on the Function of Rare-Earth Ions in Glass Matrices.** R. C. Vickery and R. Sedlacek. *Am. Ceram. Soc. J.*, Oct., 1958, pp. 422–426. 25 refs. AFOSR-supported study of the effects on density of the inclusion of low concentrations of rare-earth ions in lead silicate, soda lime, and phosphate glass matrices.

## Computers

**Multi-Variable Function Generator.** T. J. Kelley. *Instruments & Automation*, Nov., 1958, p. 1,819. Description of the function generator whose primary advantage is the ability to represent exactly complex functions of two variables and carry out a multiplication by a third variable.

**O Nakoplenii Vozmushchenii v Nestatsionarnykh Lineinykh Impul'snykh Sistemakh.** Ia. N. Roitenberg. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 534–536. In Russian. Study of the problem of accumulated disturbance in nonstationary linear pulse systems under the effect of external forces.

**Treating Transfer Functions on Analog Computers.** Cyrus Beck. *Elec. Mfg.*, Oct., 1958, pp. 94–99. Presentation of a method which permits to go directly from the transfer function to a mechanical schematic of the computer arrangement in a single step. Advantages and applications of the method are discussed along with its disadvantages. Two examples of its use are given.

**Communication Channels for SAGE Data Systems.** R. T. James. *Elec. Eng.*, Sept., 1958, pp. 792–797. Description of a system of air surveillance and control in which flight data from radars and other relevant information is gathered and evaluated continuously and automatically.

**Tones Find Data in High-Speed Tape Systems.** Reuben Wasserman and Paul Hurney. *Electronics*, Nov. 21, 1958, pp. 92–95. Description of the operation of a searcher, consisting of a digital timing generator and a magnetic tape search unit, giving automatic, high-speed access to selected data from multichannel magnetic tape-instrumentation systems.

**The R. A. E. Hollerith Punched-Card Installation (1945–1952).** R. A. Fairthorne, G. J. Griffith, and M. F. C. Woollett. *Gt. Brit., ARC R&M 3084* (Dec., 1952) 1958. 29 pp. 22 refs. BIS, New York, $1.89.

**Methods of Simulating a Differential Analyzer on a Digital Computer.** F. Lesh. *Assoc. Comp. Mach. J.*, July, 1958, pp. 281–288. OOR-sponsored description of the DEPI (Differential Equations Pseudocode Interpreter) routine; integration, programing, and coding are discussed.

**The Use of Analogue Computers in Guided Weapon Work.** Ruth Ball and G. Brown. *Aeronautics*, Aug., 1958, pp. 36, 37. Discussion underlining the growing application of electronic fact-finding equipment to the expanding field of missile research.

**Thermal Computers. III, IV.** G. A. Gedney and G. M. Davidson. *ARMA Eng.*, May-June; July-Aug., 1958, pp. 13–15; 24–29. Details of the algebraic operation of multiplication, introduction of the closed loop equivalent circuit of the multiplier, and analysis of the system to yield the allowable range of the input variables and the accuracy of the computation.

## Control Theory

**Survey of Mathematical Methods for Nonlinear Control Systems.** J. M. Loeb. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-104.*) *ASME Trans.*, Oct., 1958, pp. 1,439–1,450. 24 ref.

**Dynamic Programming and Stochastic Control Processes.** Richard Bellman. *Info. & Control*, Sept., 1958, pp. 228–239. 15 refs. Application of the functional equation techniques of the theory of dynamic programing to the formulation and computational solution of various types of variational problems arising in the study of control processes with stochastic elements.

**Optimal Synthesis of Linear Sampling Control Systems Using Generalized Performance Indexes.** R. E. Kalman and W. Koepcke. (*ASME Instr. & Reg. Conf., Newark, Del., Apr. 2-4, 1958, Paper 58–IRD-6.*) *ASME Trans.*, Nov., 1958, pp. 1,820–1,826. 21 refs.

**Time Domain Synthesis of Sampled-Data Control Systems.** E. I. Jury and F. W. Semelka. (*ASME Instr. & Reg. Conf., Newark, Del., Apr. 2-4, 1958. Paper 58-IRD-8.*) *ASME Trans.*, Nov., 1958, pp. 1,827–1,838. 17 refs.

**On Transfer Functions and Transients.** A. H Zemanian. *Quart. Appl. Math.*, Oct., 1958, pp. 273–294. 18 refs. Presentation of certain classes of functions that are defined from the system functions having any number of poles in excess of zeros such that the corresponding transient responses are restricted in a manner similar to the restrictions existing on the transient responses of positive real functions.

**The Analysis of Sampled-Data Control Systems with a Periodically Time Varying Sampling Rate.** F. J. Mullin and E. J. Jury. *U. Calif. Inst. Eng. Res., Ser. 60/207* (*AFOSR TN 58–665*) [*AD 162196*], June 30, 1958. 24 pp. 12 refs.

**Cross-Coupled Multi-Dimensional Feedback Control Systems.** P. E. Sarachik. *Columbia U. Dept. Elec. Eng. TR T-30/B* (*AFOSR TN 58-556*) [*AD 158374*], May 15, 1958. 119 pp. 24 refs. Derivation of differential equations describing the system; proofs of three stability theorems; and suggestions for a synthesis procedure which combines the nonlinear methods required to establish stability with linear designs for good dynamic behavior.

**The Effects of Quantization in Feedback Systems.** J. E. Bertram. *Columbia U. Dept. Elec. Eng. TR T-28/B* (*AFOSR TN 58-323*) [*AD 154227*], Mar. 15, 1958. 88 pp. 25 refs. Analysis to obtain a mathematical formulation which permits an easy determination of the upper bound on the error in the state variables due to quantizers in an otherwise linear sampled-data feedback system.

**Determination of the Error Co-Efficients of a Stable, Unity Feedback, Linear Servomechanism and Its Error Response for Arbitrary Forcing Functions.** Hironmoy Banerjee and Bishnupada

Bhattacharyya. *J. Techn.*, June, 1958, pp. 1–12. 12 refs.

**Backlash in Servo Systems.** R. V. Halstenberg and P. E. Russell. *Elec. Mfg.*, Dec., 1958, pp. 96–100, 274–276. Presentation of situations where backlash effects may be important. Applicable analytical techniques are summarized, and compensating methods useful in system stabilization are described.

## Education & Training

**Research for Experimental Investigations of Transferable Skills in Electronic Maintenance.** R. B. Miller and E. B. Slebodnick. *USAF PTRC TR 58-2 [AD 152104]*, Jan., 1958. 21 pp.

**Studies of the Effect Upon Aiming-Point Identification of Certain Chart Variables.** W. H. Lichte. *USAF PTRC DR TN 58-3 [AD 152112]*, Jan., 1958. 29 pp. 15 refs.

**The Influence of Chart Scale and Amount of Information on Aiming-Point Identification by Experienced Subjects.** W. H. Lichte, J. G. Miller, and C. R. Borreson. *USAF PTRC DR TN 58-2 [AD 152111]*, Jan., 1958. 24 pp.

**Refinement and Validation of an Aiming-Point Identification Motion-Picture Group Test.** S. A. Church. *USAF PTRC DR TN 57-142 [AD 146417]*, Dec., 1957. 16 pp.

**Factors in Fighter-Interceptor Pilot Combat Effectiveness.** E. P. Torrance, C. H. Rush, Jr., H. B. Kohn, and J. M. Doughty. *USAF PTRC TR 57-11 [AD 146407]*, Nov., 1957. 34 pp. 15 refs.

**An Application of the Critical-Incident Technique to Air Force Combat Leadership.** Robert Reveal, Jr., and F. L. Ruch. *USAF PTRC RR TN 58-8 [AD 152120]*, Feb., 1958. 47 pp. 28 refs.

**Adaptability Screening of Flying Personnel; Research on the Individual Test Battery.** R. M. Ritter. *USAF SAM Rep. 58-52*, Apr., 1958. 12 pp. 16 refs.

**Beschreibung des Link-Trainers ANT.18.** H. Sarnow. *DFL Inst. Luftfahrzeugf., Bericht No. 95*, May 10, 1958. 21 pp. In German. Description of the trainer ANT 18 used for ground instruction including all common aircraft instruments and primary attitude controls.

## Electronics

**Quarterly Progress Report No. 10, 15 October 1957 Through 14 January 1958.** *Polytech. Inst. Bklyn., MRI Rep. R-452.10–58*, 1958. 74 pp. 27 refs. Summaries of papers prepared by the electrophysics group, microwave techniques and devices group, and networks group.

**Quarterly Progress Report No. 11, 15 January 1958 Through 14 April 1958.** *Polytech. Inst. Bklyn., MRI Rep. R-452.11-58*, 1958. 81 pp. 35 refs. Summaries of papers prepared by the electrophysics group, microwave techniques and devices group, and networks group.

**Electronic Materials and Components for Extreme Environmental Problems: Ultrahigh Temperature, Nuclear Radiation.** A. E. Javitz and P. G. Jacobs. *Elec. Mfg.*, Nov., 1958, pp. 111–134. 49 refs.

**Analysis and Experimental Results of a Diode Configuration of a Novel Thermoelectron Engine.** G. N. Hatsopoulos and J. Kaye. *IRE Proc.*, Sept., 1958, pp. 1,574–1,579.

**Simplified Aircraft Electrical Diagrams.** H. L. Yarbrough. *Elec. Mfg.*, Sept., 1958, pp. 95–99, 303, 304. Discussion of current practice in the aircraft manufacturing industry as compared with a simplified method based on JIC Electrical Standards for Industrial Machinery. The problems created by use of current graphic methods are cited and arguments are given for the adoption of the proposed system.

### Amplifiers

**Nomographs for Designing Transistor Narrow Band Amplifiers.** L. M. Krugman. *Electronic Ind.*, Oct., 1958, pp. 78–81. 11 refs.

**Noise in Maser Amplifiers—Theory and Experiment.** J. P. Gordon and L. D. White. *IRE Proc.*, Sept., 1958, pp. 1,588–1,594. 18 refs.

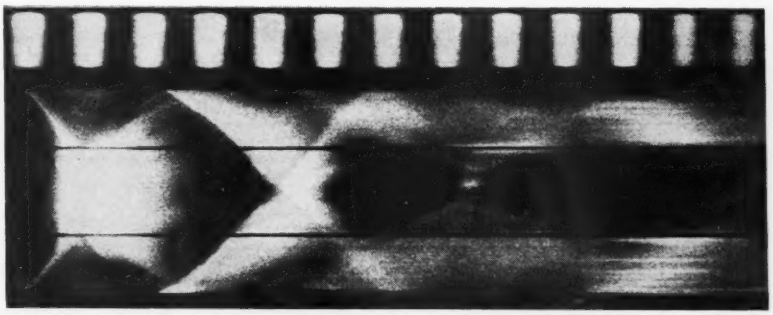
### Antennas, Radomes

**Antenna Evaluation Methods.** W. S. Lucke. *IRE Trans., AP Ser.*, July, 1958, pp. 251–254. Summary of traditional concepts of antenna evaluation, and presentation of a new evaluation method based on Shannon's formula for channel capacity. A comparison of this latter method with others is made.

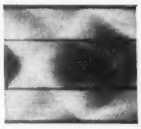
**Evaluating the Impedance Broadbanding Potential of Antennas.** A. Vassiliadis and R. L. Tanner. *IRE Trans., AP Ser.*, July, 1958, pp. 226–231. USAF-supported description of a method by which antennas can be compared on the basis of an approximate quantitative criterion. Antenna impedances are approximated and treated analytically to determine the VSWR–bandwidth relationship which may be obtained by optimum compensation.


REPORT ON

# *Plasma Propulsion at Republic Aviation*



**Space-Time Trace:** With space as ordinate and time as abscissa, photograph shows development of pinch effect in plasma, followed by shock waves. Picture was obtained with special streak camera—part of the instrumentation devised for Republic's experimental Plasma Propulsion program. Each space at top measures an interval of 10 microseconds.



An experimental Plasma Propulsion System under test at Republic Aviation gives promise of a power plant ideally suited to space vehicles. The system generates plasma from a heavy gas and subjects it to magnetic acceleration to produce thrust at high exhaust velocity.

Research and Development in Plasma Propulsion and in a number of branches of Hydromagnetics and Plasma Physics is being sharply expanded as part of Republic's new $35,000,000 Research and Development Program. Investigations currently in progress include studies of plasma generation of electricity and the application of Hydromagnetics to Hypersonics.

*Opportunities to Lead Theoretical and Experimental Research*

The Scientific Research Staff welcomes the affiliation of scientists and engineers of stature in the following fields:

HYDROMAGNETICS
PLASMA PHYSICS
GASEOUS ELECTRONICS
COMBUSTION AND DETONATION
HYPERSONICS AND SHOCK PHENOMENA
INSTRUMENTATION
PHYSICAL CHEMISTRY
HIGH POWER PULSE ELECTRONICS

Salaries commensurate with the high degree of talent and creativity required. You work with stimulating associates in a laboratory atmosphere. $14,000,000 of additional facilities now being built for Republic's new Research Center in suburban Long Island.

*Write in confidence directly to:*
DR. THEODORE THEODORSEN, *Director of Scientific Research*
**REPUBLIC AVIATION**
FARMINGDALE, LONG ISLAND, NEW YORK

**Nonresonant Slotted Arrays.** Andre Dion. *IRE Trans., AP Ser.*, Oct., 1958, pp. 360–365. Analysis of the distribution of slot conductance of nonresonant arrays by considering the array as a continuous line source. Distributions of conductance per unit length for three aperture distributions are thus obtained.

**On the Gain and Beamwidth of Directional Antennas. Appendix—Expansion of a Field in Spherical Harmonics.** R. F. Harrington. *IRE Trans., AP Ser.*, July, 1958, pp. 219–225. Presentation of a formula for the maximum gain of antennas having fields expressible as a finite number of spherical wave functions.

**Maximum Gain of a Line Source Antenna if the Distribution Function is a Finite Fourier Series.** L. Solymar. *IRE Trans., AP Ser.*, July, 1958, pp. 215–219.

**Corrective Line Sources for Paraboloids.** C. J. Sletten, R. B. Mack, W. G. Mavroides, and H. M. Johanson. *IRE Trans., AP Ser.*, July, 1958, pp. 239–251. 10 refs.

**Experimental Investigation of a Homogeneous Dielectric Sphere as a Microwave Lens.** R. N. Assaly. *Can. J. Phys.*, Oct., 1958, pp. 1,430–1,435.

**Pattern of an Antenna on a Curved Lossy Surface.** J. R. Wait and A. M. Conda. *IRE Trans., AP Ser.*, Oct., 1958, pp. 348–359. 34 refs. Presentation of numerical results for the radiation fields of electric and magnetic type antennas mounted on smooth curved surfaces of finite conductivity.

**Feasibility Study of Monolithic Foam-in-Place Radome. Appendix—Foam-in-Place Radome—Structural Analysis.** Joseph Schramp and Robert Curtis. *USAF RADC TN 58-253* [*AD 202-094*], Oct., 1958. 21 pp.

**On Satellite Type Antennas.** G. G. Weill and Cavour Yeh. *CIT AL TR 17* (*AFOSR TN 58-655*) [*AD 162186*], Aug. 30, 1958. 19 pp. Calculation of radiation patterns for two antipodal in-phase antennas and a tetrahedral array, taking into account the currents induced on the sphere.

**Performance Evaluation of HF Aircraft Antenna Systems.** E. J. Moore. *IRE Trans., AP Ser.*, July, 1958, pp. 254–260. Evaluation of antennas used for long-range voice ground-to-air and air-to-ground communications. The various antenna evaluation methods are compared theoretically for consistency and shown to lead to essentially identical results.

**Suppression of Undesired Radiation of Directional HF Antennas and Associated Feed Lines.** H. Brueckmann. *IRE Proc.*, Aug., 1958, pp. 1,510–1,516. Analysis of long-range point-to-point radio communication circuits at frequencies below MUF with respect to radiation in undesired directions, indicating some aspects useful as guide lines in antenna research, design, and application engineering.

## Circuits & Components

**Graphical Design of Transistor Bias Circuits.** G. V. Woodley. *Electronic Des.*, Nov. 26, 1958, pp. 16–19.

**Engineering Applications of Boolean Algebra IV—Circuit Design Using Boolean Matrices and System Synthesis Using State Coding.** Boris Beizer and S. W. Leibholz. *Elec. Mfg.*, Aug., 1958, pp. 108–117, 272.

**Engineering Applications of Boolean Algebra. V—Designing Sequential Circuits.** Boris Beizer and S. W. Leibholz. *Elec. Mfg.*, Sept., 1958, pp. 67–79, 298–302. 22 refs.

**Silicon Cartridge Rectifiers Are Space Savers.** J. D. Vickrey. *Mil. Electronics*, Oct., 1958, pp. 14–16.

**Microminiature Components for Electronic Circuits.** N. J. Doctor and E. M. Davies. *Elec. Mfg.*, Aug., 1958, pp. 94–97.

**The Spherical Coil as an Inductor, Shield, or Antenna.** H. A. Wheeler. *IRE Proc.*, Sept., 1958, pp. 1,595–1,602. 18 refs.

## Communications

**Foreground Terrain Effects on Overland UHF Transmissions.** L. G. Trolese and L. J. Anderson. *IRE Trans., AP Ser.*, Oct., 1958, pp. 330–337.

**Semi-Automatic Switching for Flexowriter Machines.** J. F. Greenly. *USAF RADC TN 58-289* [*AD 148957*], Nov., 1958. 10 pp.

**A Mathematical Analysis of the Kahn Compatible Single-Sideband System.** J. P. Costas. *IRE Proc.*, July, 1958, pp. 1,396–1,401.

**Effects of Satellite Spin on Ground-Received Signal.** J. T. Bolljahn. *IRE Trans., AP Ser.*, July, 1958, pp. 260–267. Analysis of spin effect showing that if the spin axis of the satellite does not coincide with the axis of symmetry of the satellite antenna system, a CW transmitted signal will be split into three closely spaced spectral components in a manner similar to the Zeeman effect in atomic spectra. The relative amplitudes of the three components are calculated for various combinations, and results are discussed.

## Construction Techniques

**Design Philosophy for High Performance Mounting Systems.** R. P. Thorn. *Mil. Electronics*, Sept., 1958, pp. 12–14. Discussion of problems involved in designing mounting systems in terms of extreme environmental conditions and high-performance requirements.

**Mounting and Retaining Printed Circuit Boards.** F. W. Wood, Jr., and T. R. Smith. *Mach. Des.*, Nov. 13, 1958, pp. 153–155.

**Printed Wiring for Airborne Electronic Equipment-Friend or Foe.** E. F. Harmon and J. J. Staller. *ARMA Eng.*, July-Aug., 1958, pp. 9–14. Evaluation of problems encountered in the design of high-reliability airborne computers based on printed wiring.

## Cooling

**Techniques of Cooling Electronic Equipment. I, II.** J. P. Welsh. *Elec. Mfg.*, Nov.; Dec., 1958, pp. 80–87, 150; 87–95, 278–280. Presentation of the theory on heat removal and techniques of temperature measurement and control. Practical methods for cooling specific electronic parts and systems are given.

**Hot Air Cools Hot Components in This Ram-Air Cooled Amplifier.** *Electronic Des.*, Dec. 10, 1958, pp. 28–31.

## Delay Lines

**Basic Types of Delay Lines.** D. L. Arenberg. *Instruments & Automation*, Oct., 1958, pp. 1,676–1,678. 14 refs. Survey including distributed-constant, lumped-constant, ultrasonic, magnetostrictive, semiconductor, and tape-recorder types.

**Designing Ultrasonic Delay Lines.** I. C. Miller and C. W. Sharek. *Electronic Des.*, July, 1958, pp. 72–76, 117, 118.

**Ultrasonic Mercury Delay Lines; Characteristics of Lines and Transducers.** C. F. Brockelsby. *Electronic & Radio Engr.*, Dec., 1958, pp. 446–452.

**Phase Relations in Delay Lines.** L. G. Burnell. *Instruments & Automation*, Oct., 1958, p. 1,675.

**Applications of Delay Lines.** D. L. Arenberg. *Instruments & Automation*, Oct., 1958, pp. 1,679–1,681. Survey of several delay line applications covering timing elements, computers, radio, and radar.

## Dielectrics

**Selection of the Shape of Specimens for Breakdown Test of Ceramic Dielectric Materials.** K. E. Medvedov. *Sov. Phys. - Tech. Phys.*, Oct., 1957, pp. 2,245–2,254. Translation.

## Magnetic Devices

**Magnetic Relaxation at High Temperature Due to Grain Boundary Slip and to Dislocations. Appendix I—Apparatus for Measuring Magnetic Relaxations. Appendix II—Preparation of Iron Single-Crystals.** Giuseppe Biorci, Andrea Ferro, and Giorgio Montalenti. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 1a* (*AFOSR TR 58-68*) [*AD 158275*], Mar., 1958. 50 pp.

**Instability of the Bloch Walls Due to Interstitial Atoms in a Ferromagnetic Lattice.** Giuseppe Biorci, Andrea Ferro, and Giorgio Montalenti. *Inst. Elettrotec. Naz. "Galileo Ferraris" TR 1c* (*AFOSR TR 58-61*) [*AD 158204*], Mar., 1958. 39 pp. 36 refs.

## Networks, Filters

**A Look at Modern Network Synthesis.** L. Weinberg. *Electronic Ind.*, Sept., 1958, pp. 67–72. 19 refs. Presentation of results for modern synthesis in the form of tables of normalized element values for various types of networks.

**Synthesis of Active Networks with Negative Impedance Converters.** R. T. Chien. *U. Ill. Eng. Exp. Sta. EERL CTG TN 4* (*AFOSR TN 58-494*) [*AD 158304*], May 5, 1958. 60 pp. 36 refs.

**Pole-Zero Sensitivity in Network Functions.** F. F. Kuo. *U. Ill. Eng. Exp. Sta. EERL CTG TN 3* (*AFOSR TN 58-495*) [*AD 158305*], May 1, 1958. 78 pp. 31 refs.

**Temperature Compensating Networks; Design of Thermistor Bias Networks for Transistor Amplifiers.** H. D. Polishuk. *Electronic & Radio Engr.*, Oct., 1958, pp. 373–377.

## Noise, Interference

**Optimum Noise Performance of Linear Amplifiers. Appendix I—Classification of Source-Free Linear Networks. Appendix II—Extrema of Noise Measure. Appendix III—Rearrangement of Variables and Reduction to Two-Terminal-Pairs.** H. A. Haust and R. B. Adler. *IRE Proc.*, Aug., 1958, pp. 1,517–1,533. 11 refs.

**Electromagnetic Noise and Propagation Observations in the Vicinity of a Nuclear Reactor.** W. W. Fain, C. M. Crain, and W. C. Duesterhoeft. *IRE Trans., AP Ser.*, July, 1958, pp. 286–288. USAF-supported research.

**Problems of Missiles; Reducing Spurious Radiation.** A. L. Albin and C. B. Pearlston, Jr. *Electronic Ind.*, Sept., 1958, pp. 59–63. Description of an experimental program designed to extend existing interference limits to cover 1-10 KMC; measuring techniques are established.

**Error Probabilities for Binary Symmetric Ideal Reception Through Nonselective Slow Fading and Noise. Appendix I—The Complex Correlation Function. Appendix II—Cross-Correlation Techniques. Appendix III—Probability of Error, Coherent Case. Appendix IV—Probability of Error, Noncoherent Case.** G. L. Turin. *IRE Proc.*, Sept., 1958, pp. 1,603–1,619. 34 refs.

**ADF Interference Blanker Development.** M. M. Newman, J. R. Stahmann, and J. D. Robb. (*IRE East Coast Conf., Aero. & Nav. Electronics, Baltimore, Oct. 29, 1957.*) *IRE Trans., ANE Ser.*, June, 1958, pp. 86–91. Description of interference blankers developed to give an improvement ratio of the order of 1,000 in the presence of severe precipitation static.

**A Comparison of Two Cathode-Ray Tubes for Signal Detectability as a Function of Random Noise Level.** R. L. Erdmann and J. W. Gunvordahl. *USAF RADC TR 58-118* [*AD 148902*], Sept., 1958. 13 pp.

## Piezoelectricity

**Methods of Measurement of the Parameters of Piezoelectric Vibrators.** E. A. Gerber and L. F. Koerner. *IRE Proc.*, Oct., 1958, pp. 1,731–1,737.

**Electron Spin Resonance in Single Crystals of $BaTiO_3$.** W. Low an D. Shaltiel. *Hebrew U. Dept. Phys. TN 1* (*AFOSR TN 58-544*) [*AD 158361*], May, 1958. 8 pp.

**The Paramagnetic Resonance Spectrum of Gadolinium in Hydrated Lanthanum Trichloride.** M. Weger and W. Low. *Hebrew U. Dept. Phys. TN 2* (*AFOSR TN 58-543*) [*AD 158360*], May, 1958. 14 pp.

## Power Supplies

**Silicon Power Rectifiers—A Survey.** J. R. Riggs. *Elec. Mfg.*, Sept., 1958, pp. 56–66.

## Radar

**Predicting Accurate Radar Ranges.** Leo Young. *Electronic Ind.*, Nov., 1958, pp. 58–61.

**Evaluation of Precipitation Effects on Radars Operating at Millimeter Wavelengths. Appendix I, II—Equations for Use in Determining the Range Where the S/N = 1. Appendix III—Attenuation Formula as Derived from the Radar Range Equation. Appendix IV—Derivation of the Pulse Volume, V.** V. J. Coyne. *USAF RADC TN 58-249* [*AD 148906*], Sept., 1958. 24 pp. 13 refs.

**Dynamic Compression for Radar Receivers. I.** Daniel Levine. *Electronic Ind.*, Oct., 1958, pp. 102–106. Discussion of parameters affecting the compression of signal levels, and presentation of a graphical analysis for different types of receivers.

**Staggered Rep Rate Fills Radar Blind Spots.** S. E. Perlman. *Electronics*, Nov. 21, 1958, pp. 82–85. Investigation covering the relocation of blind speeds in a moving target indicator, limitations of a moving-target-indicator radar system, and a staggered prf circuit compared with response to clutter fluctuation in a conventional mti system.

**Simulated Doppler Effects for Radar System Testing.** J. E. Toffer. *Electronic Des.*, Nov. 26, 1958, pp. 22, 23. Description of a technique for calculating the frequency shifts and development of a method for simulating these shifts to test receiver tracking capability.

## Reliability

**The Maintenance Side of Reliability.** R. M. Jacobs and B. F. Rogers. *Mil. Electronics*, Aug., 1958, pp. 20–22. Includes evaluation of test equipment, wiring techniques, and human factors involved.

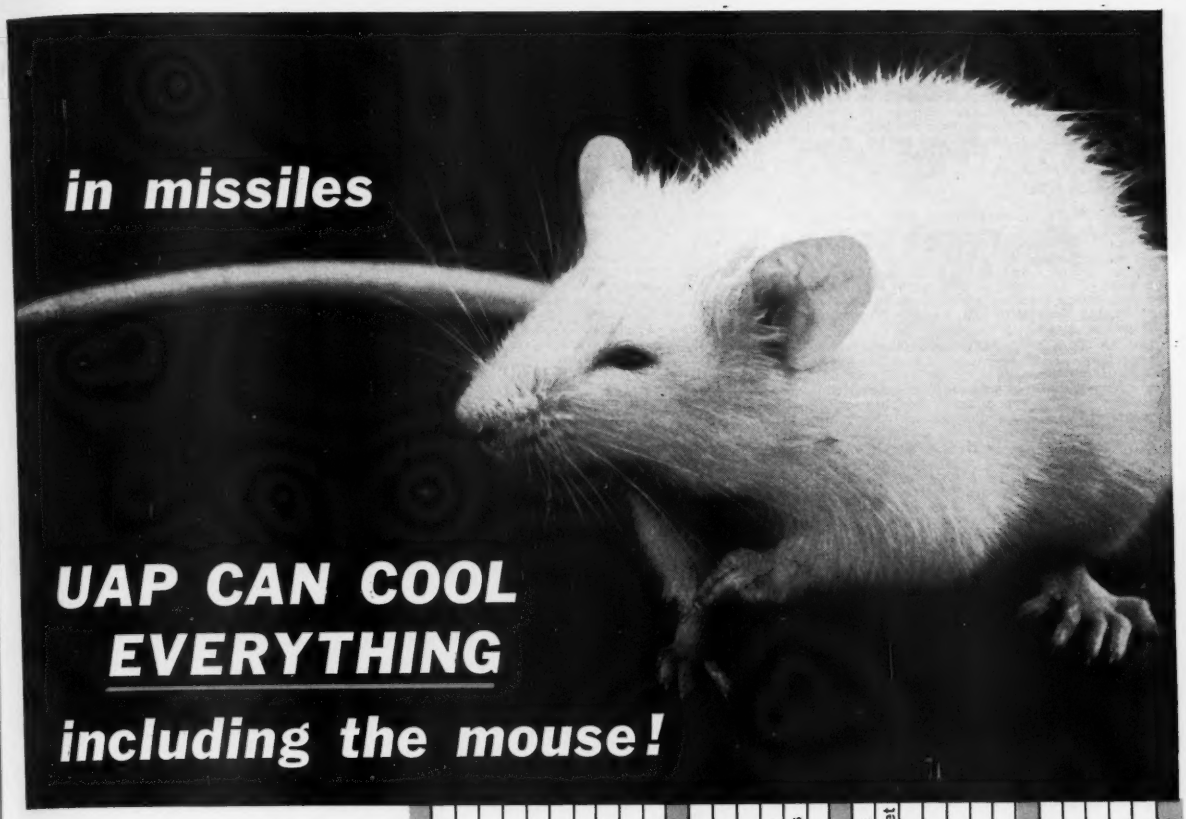
**Reliability Via the Component Part.** F. J. Ruther. *Mil. Electronics*, Aug., 1958, pp. 12–15. Evaluation of goals of a component-part reliability testing program and presentation of some experimental results.

## Resistors

**A Practical Approach to Solving Thermistor Problems.** R. S. Goodyear. *Electronic Ind.*, July, 1958, pp. 51–55, 118.

## Semiconductors

**Sovremennye Vysokochastotnye Tranzistory.** Iu. S. Riabinkin. *Uspekhi Fiz. Nauk*, Aug., 1958, pp. 689–719. 81 refs. In Russian. Survey of the development of transistors and description of certain modern types, their operation, and application.




| | missile type | Surface-Surface | Air-Surface | Air-Air | Surface-Air | ICBM | IRBM | IGBM | Drone | Tactical | Unknown | service use | Army Ordnance | USAF | NAVY | Army Sig. Corps | Bur. Aeronautics | Unknown | propulsion | Liq. Fuel Rocket | Solid Fuel Rocket | Booster | Ram Jet | Turbo Prop | Gas Turbine | Unknown | guidance | Radar | Inertial | Infra Red | Radio | Unknown | ground support |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cooling systems | Mechanical Refrigeration | | | | ■ | ■ | | | | | | | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | | ■ | |
| | Expendable Refrigeration | | | | ■ | ■ | | | | | | | ■ | ■ | | | | | | ■ | ■ | | | | | ■ | | ■ | | | ■ | |
| | Cryogenic | | | | | ■ | | | | | | | ■ | ■ | | | ■ | | | ■ | ■ | | | | | ■ | | | | | | ■ |
| | Heat Transport | | | | | | | | ■ | | | | ■ | ■ | | | ■ | | | ■ | ■ | | | | | ■ | | | | | | ■ |
| | Console Cooling | ■ | | | ■ | ■ | | ■ | | ■ | | | ■ | ■ | | | ■ | | | ■ | ■ | | | | | ■ | | ■ | | | | ■ |
| | Evaporative | ■ | | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | ■ | | | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | | ■ | ■ |
| heat exchangers | Liquid/Air | ■ | ■ | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | ■ | | | | | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | | | ■ | ■ |
| | Ammonia/Glycol | ■ | ■ | | ■ | ■ | | | | ■ | | | ■ | ■ | | | | | | ■ | ■ | | | | | ■ | | ■ | | | ■ | ■ |
| | Liquid/Gas | | | | | | | | | | ■ | | ■ | ■ | | | | ■ | | | | | ■ | | | | ■ | | | | ■ | |
| | Evaporative | | ■ | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | ■ | | | | | |
| | Liquid/Liquid | ■ | ■ | | ■ | ■ | | | | ■ | | | ■ | ■ | ■ | | | | | ■ | ■ | | ■ | | | ■ | | ■ | | | ■ | ■ |
| | Liquid Ammonia/Liq. Oxygen | | | | | ■ | | | | | | | ■ | ■ | ■ | | | | | ■ | | | | | | ■ | | ■ | | | ■ | ■ |
| | Hot Gas/Nitrogen Tetroxide | | | | ■ | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | ■ | | | | |
| | Ammonia/Air | | | | ■ | | | | | | | | ■ | ■ | | | | | | | | | | | | | | ■ | | | | |
| | Cold Plate | ■ | | ■ | | | | | | | | | ■ | ■ | ■ | | | | | | ■ | | | | | | | ■ | | | | |
| valves | Rupture | | ■ | | ■ | | | | | | | | ■ | ■ | ■ | | | | | ■ | | | | | | | | | | | | |
| | Explosive | | | | ■ | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | |
| | Bleed | | ■ | | | ■ | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | |
| | Bypass | | | | ■ | ■ | | | ■ | | | | ■ | ■ | | | | | | | | | | | | | | | | | | |
| | Temperature Control | | | | | | | | | | ■ | | ■ | ■ | | | | ■ | | | | | | | | | ■ | | | | ■ | |
| | Pressure Control | | | | | | | | | | ■ | | ■ | ■ | | | | ■ | | | | | | | | | ■ | | | | ■ | |
| | Solenoid | | ■ | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | | | | | | | | | | | | | | | | |
| | Thermostatic | | | | | | | | | | ■ | | ■ | ■ | | | | ■ | | | | | | | | | ■ | | | | ■ | |
| hand pumps | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| oil tanks | All-Attitude | | | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | ■ |

The achievement chart proves UAP's extensive experience and ability in designing and building electronic cooling systems, components and flow control devices. Whether your electronic cooling problem involves airframe, guidance, propulsion or ground control equipment, UAP has the technical know-how to solve it! Call your UAP Contractual Engineering Office today!

CALIFORNIA, Burbank.....VI 9-4236 OHIO, Dayton.....BA 4-3841
NEW YORK, New York....MU 7-1283 CANADA, Montreal.....ME 1-4396

*a famous family of aircraft essentials since 1929*

**UNITED AIRCRAFT PRODUCTS, INC.**
1116 BOLANDER AVENUE, DAYTON, OHIO

UAP
UNITED AIRCRAFT PRODUCTS

### *Telemetry*

**Theory of Operation of a Receiver for Multiplex Cyclic Telemetry.** V. N. Zhilin. *Sov. Phys.-Tech. Phys.*, Oct., 1957, pp. 2,226–2,231. Translation. Analysis considering the behavior of the tube circuit containing the memory capacitor using the method of successive integration which gives the solution of the problem for the steady state as well as for the transient state.

### *Transmission Lines*

**Guided Wave Propagation in Submillimetric Region.** A. E. Karbowiak. *IRE Proc.*, Oct., 1958, pp. 1,706–1,711. Analysis of electromagnetic wave propagation in wave guides and in TEM transmission lines as the frequency is raised indefinitely. It is shown that with TH waves the attenuation becomes a more rapidly decreasing function than with TE waves. Numerical examples are given.

**On the Theory of Anisotropic Obstacles in Waveguides.** Walter Hauser. *Quart. J. Mech. & Appl. Math.*, Nov., 1958, pp. 427–437. USAF-Army-Navy-supported presentation of variational principles for the approximate computation of elements of the scattering matrix for anisotropic obstacles in wave guides.

**On the Attenuation of Guided Waves in the Limit of High Frequencies.** Ch. H. Papas. *CIT AL TR 15 (AFOSR TN 58–462) [AD 158-269]*, Mar. 29, 1958. 9 pp. Derivation of attenuation formulas taking into account the high-frequency anisotropy of the surface resistance.

**Low-Loss Structures in Waveguides; Experimental Evaluation of Equivalent Circuit Parameters.** M. F. McKenna. *Electronic & Radio Engr.*, Dec., 1958, pp. 470–472.

**Reflectionless Bead for Symmetrical Strip Transmission Line.** K. S. Packard. *Electronic Des.*, Nov. 26, 1958, pp. 20, 21. Description of the design of a reflectionless bead for supporting the center conductor of a strip transmission line.

**Phase-Shift at Microwave Frequencies; Measurements on Waveguide Components.** M. H. N. Potok. *Electronic & Radio Engr.*, Oct., 1958, pp. 382–386.

**Methods of Reducing Chromatic Aberration in Metal-Plate Microwave Lenses.** E. K. Proctor. *IRE Trans., AP Ser.*, July, 1958, pp. 231–239.

### *Wave Propagation*

**Current Distribution in Modulated Magnetically Focused Electron Beams.** M. Chodorow, H. J. Shaw, and D. K. Winslow. *J. Appl. Phys.*, Nov., 1958, pp. 1,525–1,533. USAF-Army-Navy-supported presentation of d.c. and r-f current distribution in a modulated, magnetically focused electron beam having normalized parameters in a range of values appropriate for medium- and high-power klystrons.

**Interferentsiia Elektronnykh Voln.** V. I. Miliutin. *Uspekhi Fiz. Nauk*, Aug., 1958, pp. 665–688. 25 refs. In Russian. Description of experiments on the interference of electronic waves, including a survey of certain interferometers and their application.

**Variational Principles for Guided Electromagnetic Waves in Anisotropic Materials.** Walter Hauser. *Quart. Appl. Math.*, Oct., 1958, pp. 259–272. USAF-Army-Navy-supported development of a general method for obtaining approximate solutions to the problems on the propagation of waves in a guide which may only be partially filled with material having tensor electromagnetic properties.

**Scattering of Plane Waves by Locally Homogeneous Dielectric Noise.** R. A. Silverman. *Cambridge Philos. Soc. Proc.*, Oct., 1958, pp. 530-537. Comparison of two approaches to the problem of scattering of incident plane waves by a confined region of dielectric noise.

**Variational Principles in High-Frequency Scattering.** R. D. Kodis. *Cambridge Philos. Soc. Proc.*, Oct., 1958, pp. 512–529. 19 refs. USAF-supported formulation of a pair of variational principles for two-dimensional scattering by obstacles.

**Simultaneous Variation of Amplitude and Phase of Gaussian Noise, with Applications to Ionospheric Forward-Scatter Signals.** T. Hagfors and B. Landmark. *(IEE Paper 2743 R.) IEE Proc., Pt. B*, Nov., 1958, pp. 555–559.

**Incoherent Scattering of Radio Waves by Free Electrons with Applications to Space Exploration by Radar.** W. E. Gordon. *IRE Proc.*, Nov., 1958, pp. 1,824–1829. USAF-sponsored research.

**Approximate Computation of the Diffraction of Plane Electromagnetic Waves at Certain Metal Bodies.** P. Ia. Ufimtsev. *Sov. Phys.-Tech. Phys.*, Aug., 1957, pp. 1,708–1,718. Translation.

**Some Generalized Scattering Relationships in Transhorizon Propagation.** A. T. Waterman, Jr. *IRE Proc.*, Nov., 1958, pp. 1,842–1,848. 23 refs. Army-supported study of the general consequences in assuming that the pertinent mechanism of turbulent scattering is a single-scattering process distributed systematically throughout the atmosphere.

**Investigation of Long-Distance Overwater Tropospheric Propagation at 400 MC.** H. E. Dinger, W. E. Garner, D. H. Hamilton, Jr., and A. E. Teachman. *IRE Proc.*, July, 1958, pp. 1,401–1,410.

**Scanning Surface Wave Antennas—Oblique Surface Waves Over a Corrugated Conductor.** R. W. Hougardy and R. C. Hansen. *IRE Trans., AP Ser.*, Oct., 1958, pp. 370–376. 12 refs.

**Altitude Variation of Field Strength for Vertically Polarized Low and Broadcast Frequency Radiation.** J. R. McGonegal, J. W. Savage, and C. A. Zielinski. *IRE Trans., AP Ser.*, July, 1958, pp. 278–281. USAF-supported investigation.

**Atmospheric Effects on VHF and UHF Propagation.** G. H. Millman. *IRE Proc.*, Aug., 1958, pp. 1,492–1,501. Presentation of tropospheric refractive index profiles and ionospheric electron density models representative of average atmospheric conditions. Mathematical relationships are derived for calculating refraction effects, time delays, Doppler errors, polarization changes, and attenuation experienced by radio waves traversing the entire atmosphere.

**Solar Cycle Influence on the Lower Ionosphere and on VHF Forward Scatter.** C. Ellyett and H. Leighton. *IRE Proc.*, Oct., 1958, pp. 1,711–1,716. 26 refs.

### *Wave Theory*

**Surface Waves.** H. M. Barlow. *IRE Proc.*, July, 1958, pp. 1,413–1,417. 17 refs. Examination of three forms of surface waves; the problems of launching and supporting are considered, and their behavior and applications are discussed.

**A Helical Coordinate System and its Applications in Electromagnetic Theory.** R. A. Waldron. *Quart. J. Mech. & Appl. Math.*, Nov., 1958, pp. 438–461.

**Refraction Anomalies in Airborne Propagation.** M. S. Wong. *IRE Proc.*, Sept., 1958, pp. 1,628–1,638. 15 refs. Portrayal of the anomalies encountered by ray tracings. These are: dense fadings, radio holes and antiholes, and ducting. Radar angular and range error are also shown.

**Transcendental Equations in Electromagnetic Theory.** Leon Kotin and Wilhelm Magnus. *NYU Inst. Math. Sci., Div. Electromagn. Res., Res. Rep. BR-27 (AFOSR TN 58-749) [AD 201-501]*, Aug., 1958. 38 pp.

## Equipment

**Now You Can Specify Plastics Pressure Vessels.** A. J. Wiltshire. *Materials in Des. Eng.*, Nov., 1958, pp. 101–104. Discussion on the common types, design, and application of plastic pressure vessels. A comparison with metal vessel materials is made.

### *Electric*

**Note on the Assessment of Explosion Risks Associated with Electrical Equipment on Aircraft.** A. H. Mitchell. *Gt. Brit., RAE TN El.151*, June, 1958. 16 pp.

**L'Equipement Electrique du Bristol "Britannia." I—Schémas de Principe de la Production et de la Régulation des Courants.** H. Lanoy. *Docaéro*, Sept., 1958, pp. 25–40. In French. Study of the electric equipment used for the Bristol Britannia, covering problems encountered in modern transport aircraft and means for eliminating them.

**Wires and Cables: Vital to Missiles.** Peer Fossen and R. M. Nolan. *Missiles & Rockets*, Sept. 8, 1958, pp. 23–32. Description of new developments in the wire and cable field. The properties and possible use of Teflon as an insulation product for missile wiring are reviewed, and the cabling machine and its operation are described.

**Special Report on the Solid Inverter.** D. W. Moore and R. D. Gates. *Western Av.*, Nov., 1958, pp. 6, 7. Discussion of the design approach and operating characteristics of a 500 va., 400 cps, three-phase transistorized inverter intended for use in supersonic vehicles.

### *Hydraulic & Pneumatic*

**High Pressure Pneumatics—Can it Replace Hydraulics?** H. E. Wright. *Appl. Hydraulics & Pneumatics*, Nov., 1958, pp. 114–118. Comparison of the actuating cylinders, transmission lines, and energy sources for the two types of equipment.

**Aircraft Reliability Demands Leakproof Hydraulics.** E. T. Raymond and J. W. Hull. *Appl. Hydraulics & Pneumatics*, Oct., 1958, pp. 74–77. Discussion of the development of leakproof hydraulic systems, various seal designs, and materials for improved reliability.

**Hydraulic System Design for Future Aircraft.** W. E. Mayhew. *Appl. Hydraulics & Pneumatics*, Dec., 1958, pp. 96–98. Discussion covering the design problems of hydraulic systems due to the effect of high operating temperatures on hydraulic fluids, construction, and sealing materials; possible solutions are presented.

**Hydraulic Turbopump Power in a Small Package.** M. C. Toth. *Appl. Hydraulics & Pneumatics*, Oct., 1958, pp. 114, 115.

**The Compressive Instability of a Hydraulic Jack.** E. Kosko. *UTIA Rep. 55*, Aug., 1958. 24 pp.

**A Low-Speed, High-Frequency Alternator.** *de Havilland Gazette*, Aug., 1958, pp. 140, 141. Description of the B. 507, a compact, low-speed, hydraulically driven alternator.

## Fuels & Lubricants

**Keeping Fuel Clean Enough for Turbines.** C. E. Loeser, D. D. Love, and A. R. Ogston. *SAE J.*, Nov., 1958, pp. 55–57. Abridged.

**High-Energy Fuels for Aviation.** R. A. Wells. *(ASME Joint Av. Conf., Dallas, Mar. 16-20, 1958, Paper 58-AV-26.) Mech. Eng.*, Sept., 1958, pp. 55–59. 13 refs. Comparison of several high-energy fuels with standard JP-4 and kerosene fuels considering turbojet, ram-jet, and rocket applications. Advantages and disadvantages are discussed in each case.

**Fundamental Studies of Lubrication.** F. W. Smith. *Canada, NAE Quart. Bul.*, Apr. 1–June 30, 1958, pp. 1–8. 10 refs. Investigation of the behavior of lubricants in machine components such as ball bearings and gears where concentrated loads act on the regions of contact.

**Screw Extrusion Theory with Application to Double-Base Propellant.** M. L. Jackson, F. J. Lavacot, and H. R. Richards. *Ind. & Eng. Chem.*, Oct., 1958, pp. 1,569–1,576. 15 refs. Discussion of the screw theory for non-Newtonian materials.

**Solid Fuels Vie for Propellant Lead.** A. J. Zaehringer. *Missiles & Rockets*, Aug. 11, 1958, pp. 28–37. Discussion on the most critical areas for future solid rockets: scale-up, production, new materials and supply, and safety.

**Rocket Working Fluids; Hydrogen and Helium.** R. L. Potter, G. E. Guffner, and T. F. Reinhardt. *Ind. & Eng. Chem.*, Oct., 1958, pp. 1,557–1,560. Discussion exploring the performance potentialities of hydrogen and helium as inert working fluids in a rocket using a separate heat source.

**Free Radicals for Propulsion.** Y. C. Lee and S. T. Demetriades. *SAE J.*, Aug., 1958, pp. 60–62. Survey of the performance limits and other penalties associated with the use of free radicals and other high-energy fuels including solid, liquid, and gaseous propellants.

**Heats of Formation of Diborane and Pentaborane.** E. J. Prosen, W. H. Johnson, and F. Y. Pergiel. *J. Res.*, Oct., 1958, pp. 247–250. 10 refs. Experimental determination of the heats of formation of diborane and pentaborane by measurements of the heats of decomposition into amorphous boron and hydrogen in a calorimeter.

**Thermodynamics of $Al_2O_3$.** Milton Farber. *Jet Propulsion*, Nov., 1958, pp. 760–762.

**Toxicity and Personal Decontamination of Boron Hydride Propellant Fuels.** Sidney Rothberg, J. L. Colbourn, and Robert Salvatore. *Jet Propulsion*, Nov., 1958, pp. 762–764.

## Instruments

**Radio Interferometers Track Airborne Vehicles.** M. W. Miles. *Electronic Ind.*, Oct., 1958, pp. 94, 95, 151–153. Application of a geometric radio phase-difference method to provide continuous airborne vehicle directions.

### *Flight Instruments*

**New Instrument Indicates Take-Off Progress.** Jack Andresen and E. H. Schroeder. *SAE J.*, Aug., 1958, pp. 72, 73. Brief description of the design and operating principles of a device for jet aircraft application.

### *Flow Measuring Devices*

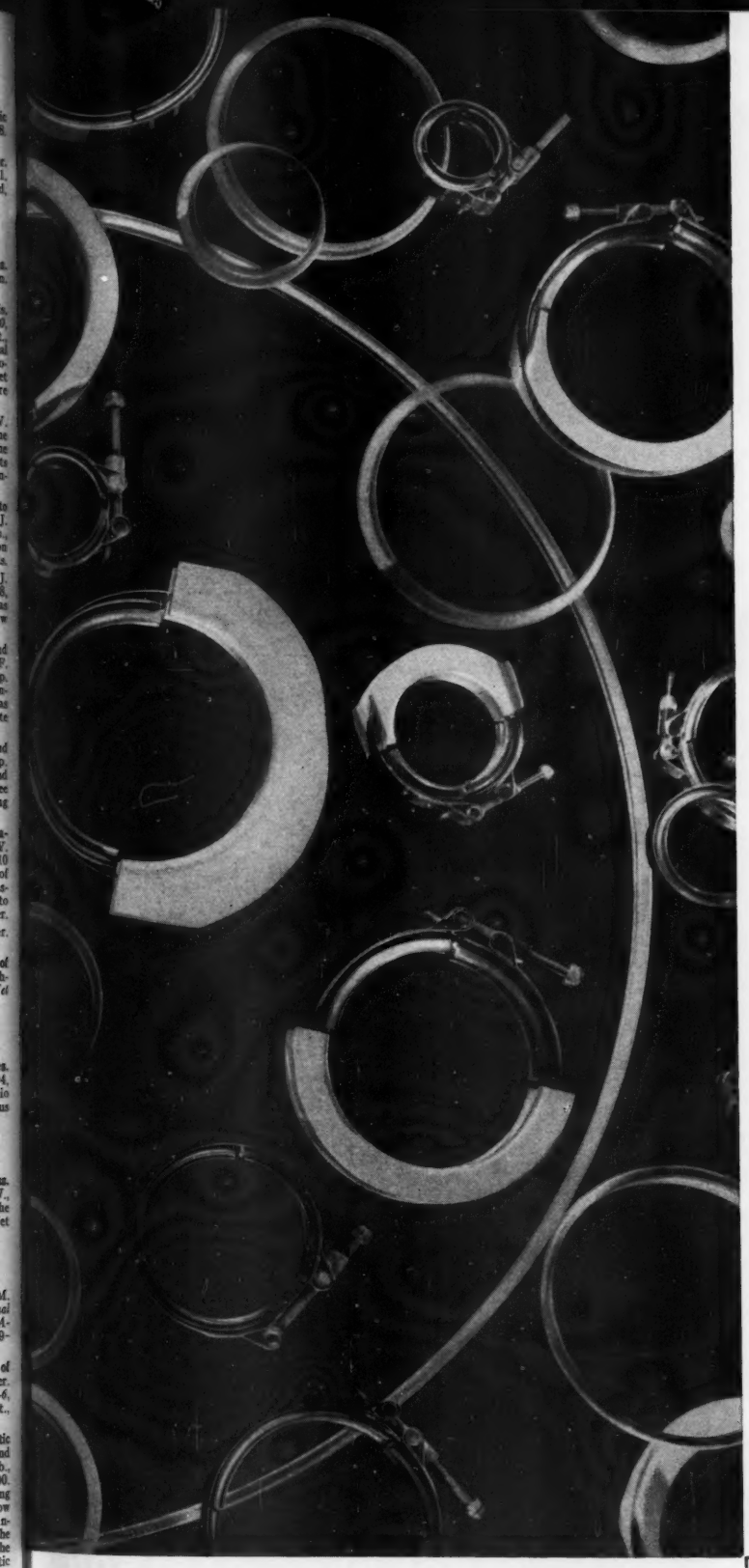
**Liquid-Flowmeter Calibration Techniques.** M. R. Shafer and F. W. Ruegg. *(ASME Annual Meeting, New York, Dec. 1-6, 1957, Paper 57-A-70.) ASME Trans.*, Oct., 1958, pp. 1,369–1,375; Discussion, pp. 1,376–1,379. 15 refs.

**Dimensionless Correlation of Coefficients of Turbine-Type Flowmeters.** H. M. Hochreiter. *(ASME Annual Meeting, New York, Dec. 1-6, 1957, Paper 57-A-63.) ASME Trans.*, Oct., 1958, pp. 1,363–1,368.

**The Pressure in a Two-Dimensional Static Hole at Low Reynolds Numbers.** A. Thom and C. J. Apelt. *Gt. Brit., ARC R&M 3090* (Feb., 1957) 1958. 13 pp. BIS, New York, $0.90. Description of an arithmetic method for obtaining solutions for steady incompressible viscous flow at low Reynolds Numbers in the form of expansions in powers of the Reynolds Numbers. The method has been used to find a solution for the flow past the mouth of a two-dimensional static hole.

### *Gyroscopes*

**Achieving Extremely Accurate Nonfloated Gyros.** A. W. Lane, M. S. Klemes, and E. L. Zeigler. *Aero/Space Engrg.*, Jan., 1959, pp. 43–46. Discussion of the Rotorace bearing principle for activating a gyro gimbal bearing in such a manner that the average torque level of the bearing is reduced by a factor of at least ten.



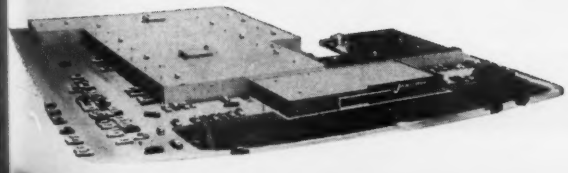
# *reliable couplings unlimited*

Thousands of Janitrol couplings for high-temperature high-pressure ductwork are proving their reliability on advanced aircraft and missiles: DC-8, 720, 880, 707, KC 135, CF 105 (Mark I and II), F4H, F8U3, P6M, S-55, HR-251, H19D4, H34A, H37A, Regulus II and the Green Quail.

Couplings are furnished in titanium as well as stainless steel; sizes range from 1″ to 36″ diameter. Janitrol coupling reliability is firmly based on a unique combination of research, design, testing and manufacturing facilities capable to handle complete systems including heat exchangers, coolers, and controls.

Call the Janitrol representative near you for help early in the design stage.

Janitrol Aircraft Division
Surface Combustion Corporation
4200 Surface Road
Columbus 4, Ohio



JANITROL

A TALENT
FOR
WEAPONS
TEST EQUIPMENT
STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS CORPORATION
1400 NORTH GOODMAN STREET • ROCHESTER 3, N. Y.
ELECTRONICS AND COMMUNICATION FOR HOME, INDUSTRY AND DEFENSE

*Critical problems in weapons system testing: the reduction of test time with increased test reliability . . . the reduction of equipment costs with increased test flexibility.*

The search for a system meeting these requirements has led to the SCATE concept of standardized block design.

SCATE—Stromberg-Carlson Automatic Test Equipment—embodies existing hardware as a nucleus.

Implementation with special stimulus generators and response monitors rounds out the SCATE system, which meets the testing needs of any weapons system, component, or sub-assembly . . .

and is flexible; self-checking, self-calibrating . . . brings lower cost, new speed and reliability to weapons testing.

Brochure available on request.

SC GD

**Kinematic Drift of Single-Axis Gyroscopes.** R. H. Cannon, Jr. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-72.*) *J. Appl. Mech.*, Sept., 1958, pp. 357–360. Study of the kinematic drift of an unrestrained single-degree-of-freedom gyro resulting from oscillatory precession of the gyro momentum vector from its nominal spatial orientation. The magnitude of the drift can be accurately predicted and the vibration climate of the platform restricted accordingly. Quantitative experimental verification is presented.

**Ob Ustoichivosti Dvizheniia Giroskopa v Kardanovom Podvese. II.** V. V. Rumiantsev. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 499–503. In Russian. Study of the stability of certain motions of a heavy symmetrical gyroscope on a gimbal support for the case where the fixed axis of the external ring is horizontal.

**Effect of Finite Rotations on Gyroscopic Sensing Devices.** L. E. Goodman and A. R. Robinson. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-30.*) *J. Appl. Mech.*, June, 1958, pp. 210–213. 10 refs. Development of a simple method for determining orientation from the time history of three body components of angular velocity by means of a new theorem in kinematics. It is shown that a gyro subjected to a regime of rotations which returns it to the original space orientation will, in general, produce a residual signal. Implications of the theorem for the design and testing purposes are discussed.

### *Panels & Dials*

**Control Panel Design and Human Engineering. I—Instrument Design for the Elimination of Errors in Use.** R. Bilinski. **II—Five Elements of a Good Control Panel.** D. R. Witt. **III—Control Knobs for Military Electronic Equipment.** T. G. Nessler. *Elec. Mfg.*, Sept., 1958, pp. 110–118.

**Man-Machine Systems Call for Displaying Integrated Instrumentation.** D. G. Aid and Charles Süsskind. *Electronic Ind.*, July, 1958, pp. 68–71. Description of a method for integrating and displaying flight information through a flat screen known as the contact analog.

### *Pressure Measuring Devices*

**Pressure Scanning System.** F. Michaels and P. Straight. *Instruments & Automation*, Aug., 1958, pp. 1,366, 1,367. Description of a system used in testing aircraft engines and missiles, including two basic approaches, test procedures, and experimental results.

**Lag in Pressure Systems at Extremely Low Pressures.** W. T. Davis. *U.S., NACA TN 4334*, Sept., 1958. 16 pp. Derivation of a theoretical formula for determining time lags in pressure-measuring systems at extremely low pressures where free molecular flow occurs. The validity of the derivation is checked experimentally.

### *Recording Equipment*

**Converting Recorders to Rectilinear Outputs.** N. D. Diamantides. *Electronic Ind.*, Oct., 1958, pp. 82–84.

### *Temperature Measuring Devices*

**Recent Advances in Transient Surface Temperature Thermometry.** J. G. Hall and A. Hertzberg. *Jet Propulsion*, Nov., 1958, pp. 719–723. 38 refs. Discussion of the development made over the last 5 years in the field of shock-tube and shock-tunnel heat-transfer research.

**A Cooled-Gas Pyrometer for Use in High-Temperature Gas Streams.** L. N. Krause, R. C. Johnson, and G. E. Glawe. *U.S., NACA TN 4383*, Sept., 1958. 32 pp. Description of an immersion-type pyrometer that utilizes the controlled cooling of a continuously aspirated sample of the gas whose temperature is to be measured. The gas is cooled as it is drawn through a tube, after which its temperature is measured with a thermocouple.

### *Vibration Measuring Devices*

**Method for Analyzing Vibration at a Surface Point.** J. S. Arnold and J. G. Martner. *Rev. Sci. Instr.*, Sept., 1958, pp. 779–783. USAF-supported development of a biaxial vibration pickup using acceleration-responsive piezoelectric transducers.

**Stroboscopic Interferometer for Vibration Measurement.** E. R. Smith, S. Edelman, E. Jones, and V. A. Schmidt. *ASA J.*, Sept., 1958, pp. 867–870. 11 refs. USAF-Navy-sponsored research.

## Machine Elements

### *Bearings*

**Design Data for Flat Air Bearings Under Steady Load Conditions.** H. L. Wunsch. *The Engr.*, Sept. 12, 1958, pp. 411–417.

**Slipper Bearings and Vibration Control in Small Gas Turbines.** H. C. Hill. (*ASME Gas Turbine Power Conf., Wash., Mar. 2–6, 1958, Paper 58-GTP-6.*) *ASME Trans.*, Nov., 1958, pp. 1,756–1,764.

**Static and Dynamic Characteristics of Compensated Gas Bearings.** H. H. Richardson. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-138.*) *ASME Trans.*, Oct., 1958, pp. 1,503–1,509. USAF-supported study.

### *Fastenings*

**Fatigue of a Nut and Bolt.** P. B. Walker. (*RAeS J.*, June, 1958, pp. 395–407.) *Gt. Brit., RAE Rep. Struc. 238*, June, 1958. 41 pp.

### *Gears & Cams*

**High-Capacity Gears.** R. Y. Scapple. *Mach. Des.*, Nov. 13, 1958, pp. 146–152. Discussion of metallurgical factors influencing design and manufacture of high-strength precision gears.

### *Rotating Discs & Shafts*

**Further Studies of Stress Distribution in Rotating Disks and Cylinders Under Elevated-Temperature Creep Conditions.** A. M. Wahl. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-91.*) *J. Appl. Mech.*, June, 1958, pp. 243–250.

**Gyroscopic Loading Tests on a Gas-Turbine Rotor.** W. K. Wilson. *IME Proc.*, No. 27, 1957, pp. 777–790; Communications, pp. 791–793; Author's Reply, pp. 793, 794. Investigation to discover how fracture is initiated in hub-shaft flanges and to explore that portion of the fatigue diagram not normally investigated in any great detail.

**Application of the Griffith-Irwin Theory of Crack Propagation to the Bursting Behavior of Disks, Including Analytical and Experimental Studies.** D. H. Winne and B. M. Wundt. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-249.*) *ASME Trans.*, Nov., 1958, pp. 1,643–1,655; Discussion, pp. 1,655–1,658. 46 refs.

## Materials

**Problème de la Qualité des Aciers Destinés aux Constructions Aéronautiques.** A. Rabey. *Docaéro*, Sept., 1958, pp. 17–24. In French. Discussion of problems covering the quality of steels used for aeronautical structures. Includes graphical representation of mechanical properties, as well as discussion of criteria for homogeneity and inclusions.

**Strength and Fatigue Tests on 20 cwt. Steel Wire Ropes.** J. G. Gasper and N. J. F. Gunn. *Gt. Brit., RAE TN Met. 287*, Apr., 1958. 15 pp.

**Designing with Stainless Steel.** *Elec. Mfg.*, Dec., 1958, pp. 79–86. Discussion of the properties, fabrication, and application of stainless steels as used in equipment design.

**Magnetic Properties of Stainless Steels.** W. S. Eberly. *Elec. Mfg.*, Sept., 1958, pp. 91–94, 302, 303.

**Some Correlations Regarding the Mechanical Strength of Materials Obtained by Sintering of Powdered Metals. III—Case When Powder Mixtures Contain Easily Fusible Components.** B. Ia. Pines, A. F. Sirenko, and N. I. Sukhinin. *Sov. Phys.-Tech. Phys.*, Aug., 1957, pp. 1,773–1,779. Translation.

**Sintering of Multi-Phase Bodies. III—Sintering of Mixtures Containing Low-Melting-Point Powders.** B. Ia. Pines, A. F. Sirenko, and N. I. Sukhinin. *Sov. Phys.-Tech. Phys.*, Aug., 1957, pp. 1,763–1,772. Translation.

### *Ceramics & Ceramals*

**Ceramics.** *Ind. & Eng. Chem.*, Sept., 1958, pp. 1,433–1,437. 60 refs. Discussion covering the development, properties, and application of ceramics.

**A Survey of the Bonding of Cermets to Metals.** G. R. Van Houten. *Welding J. Res. Suppl.*, Dec., 1958, pp. 558-s–569-s. 168 refs. Survey of the literature reviewing metallizing history; joint design and materials; methods of wetting, increasing braze strength, and correcting for differential expansion; and other topics pertinent to the production of a strong high-temperature braze for cermets.

**Meteorites, Satellites, and Ceramics.** J. S. Rinehart. (*Am. Ceram. Soc. 60th Annual Meeting, Pittsburgh, Apr. 28, 1958.*) *Am. Ceram. Soc. Bul.*, Nov., 1958, pp. 461–467. Discussion of meteorite fall, the ablation effects on meteorites, and applications of these effects to the study of ceramic nose cones.

### *Corrosion & Protective Coatings*

**An Investigation of the Effects of Atmospheric Corrosion on the Fatigue Life of Aluminum Alloys.** H. A. Leybold, H. F. Hardrath, and R. L. Moore. *U.S., NACA TN 4331*, Sept., 1958. 17 pp. Description of fatigue tests conducted on 100 vibrating cantilever sheet specimens by applying 4,000 cycles of load in a 10-min. period each day while

the specimens were subjected to atmospheric conditions over a period of several months.

### High Temperature

**2000 F Structures Are Possible Now.** H. A. Pearl. *SAE J.*, Aug., 1958, pp. 70, 71. Brief discussion of the need for examining simultaneously the materials to be used and the type of design, including thermal insulation barriers or cooling systems.

### Metals & Alloys

**Chromium Gives Stainless Properties to Iron-Aluminum Alloys.** B. King, J. J. Mueller, N. N. Ida, and F. G. Tate. *SAE J.*, Oct., 1958, pp. 48–52. Discussion covering problems in Fe-Al alloy development, properties of experimental alloys, and means of improving these properties.

**Weldability of 3 ½% Ni-Cr-Mo Steel.** C. L. M. Cottrell and K. Winterton. *Brit. Welding J.*, Oct., 1958, pp. 481–484. Study of transformation characteristics and mechanical properties of nickel-chromium-molybdenum steel.

**O Vliianii Neobratimykh Strukturnykh Izmenenii, Voznikaiushchikh pri Plasticheskoi Deformatsii, na Diffuzionnuiu Podvizhnost'.** S. Z. Bokshtein, T. I. Gudkova, A. A. Zhukhovitskii, and S. T. Kishkin. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 1,015–1,018. 10 refs. In Russian. Investigation of the effect of irreversible structural modifications, due to plastic deformation at high temperature, on the diffusion mobility of cert metals.

**O Znacheniiakh Energii Aktivatsii Samodiffuzii v Zhidkikh Metallakh.** K. A. Osipov. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 1,019, 1,020. 11 refs. In Russian. Study covering the activation energy values for spontaneous diffusion in liquid metals.

**On the Fracture of Metals.** Masuji Uemura. *Tokyo U. Aero. Res. Inst. Rep. 334*, Aug., 1958. 53 pp. 44 refs. Presentation of a general phenomenological fracture criterion for polycrystalline metals, and analysis of the stress and strain distributions at the moment of fracture of mild steel round bars having hyperbolic notches.

**The Effect of Atmospheric Corrosion on Metal Fatigue.** N. J. Wadsworth and J. Hutchings. *Philos. Mag., 8th Ser.*, Oct., 1958, pp. 1,154–1,166. Presentation of test results for copper, aluminum, and gold specimens fatigued at various pressures in air and other gases. The fatigue life is determined and the growth of cracks is studied.

**The Effect of Size on the Fatigue Strength of Four Aluminium Alloys.** N. J. F. Gunn. *Gt. Brit., RAE TN Met. 275*, Apr., 1958. 30 pp. Experimental investigation indicating that, as the tensile strength of the material increases, the size effect diminishes until there is little difference in the fatigue strength of the largest and smallest specimens.

**The Effect of Stopping Holes on the Development of Fatigue Cracks in Plate.** G. Wallgren and E. Rudin. (*FFA Rep. HU-534*, 1954.) *Gt. Brit., RAE Lib. Transl. 703*, Apr., 1958. 15 pp. Test results indicating that a stopping hole will increase fatigue life depending on the hole diameter and its position.

**Hi-Temp Metallurgy: 1200-5500°F. I—New Frontiers of Hi-Temp Metallurgy.** L. P. Jahnke. **II—Cermet Coatings in Hi-Temp Metallurgy.** J. V. Long. *Western Av.*, June, 1958, pp. 8–11.

**Thermal Fatigue of Ductile Materials. I—Effect of Variations in the Temperature Cycle on the Thermal-Fatigue Life of S-816 and Inconel 550.** F. J. Clauss and J. W. Freeman. *U.S., NACA TN 4160*, Sept., 1958. 61 pp. 21 refs. Investigation of the effects of the following factors on fatigue life: (a) maximum cycle temperature, (b) temperature difference of cycling, (c) cyclic time of exposure at the maximum cycle temperature, and (d) cyclic plastic strain.

**Thermal Fatigue of Ductile Materials. II—Effect of Cyclic Thermal Stressing on the Stress-Rupture Life and Ductility of S-816 and Inconel 550.** Appendix—**Literature Review on Mechanism of Failure.** F. J. Clauss and J. W. Freeman. *U.S., NACA TN 4165*, Sept., 1958. 43 pp. 33 refs. Investigation on the changes in the stress-rupture life, ductility, hardness, and microstructure of specimens that have been exposed to varying amounts and conditions of thermal fatigue.

**Diagrammy Sostav–Zharoprochnost pri Sootvetstvennykh Temperaturakh.** M. V. Zakharov and L. I. Karpenko. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 31–36. In Russian. Presentation of data on binary and ternary alloys in terms of composition/heat-resistance diagrams.

**Issledovanie Strukturnykh Izmenenii v Nikel'-Khromovom Splave pri Polzuchesti.** G. Ia. Kozyrskii, V. A. Kononenko, and P. N. Okrainets. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 90–92. In Russian. Presentation of experimental results on structural changes of nickel-chrome alloys under the conditions of creep.

**O Vremeni Razrusheniia v Usloviiakh Polzuchesti.** L. M. Kachanov. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 26–31. 11 refs. In Russian. Tentative theoretical determination of the rupture time for metals subjected to elevated temperatures.

### Metals & Alloys, Nonferrous

**New Engineering Metals.** J. P. Denny and L. F. Kendall, Jr. (*ASME Design Eng. Conf., Chicago, Apr. 14–17, 1958, Paper 58–MD–4.*) *Mech. Eng.*, Aug., 1958, pp. 67–71. Brief presentation of mechanical properties and discussion of applications of the following metals: zirconium, hafnium, vanadium, columbium, tantalum, chromium, and rhenium.

**Further Evaluation of Ni-Cr-B and Au-18Ni Brazing Alloys.** W. H. Chang. *Welding J. Res. Suppl.*, Dec., 1958, pp. 535-s–542-s. Evaluation of the tensile and impact properties of AISI 347 and of AISI 410 butt joints brazed with Ni-Cr-B and Au-18Ni alloys. Data are presented showing the changes of these properties as affected by temperature and/or joint clearance between room temperature and 1,200°F.

**Beryllium Machining Characteristics.** D. R. Walker. (*ASME Semi-Annual Meeting, Detroit, June 15–19, 1958, Paper 58–SA–43.*) *Mech. Eng.*, Aug., 1958, pp. 57–62.

**Low Temperature Properties of Aluminium-Magnesium Alloys.** R. E. Lismer. *Brit. Welding J.*, Nov., 1958, pp. 523–538. Results of a series of tests made on certain light alloys in the wrought and welded conditions.

**Tear Tests on Aluminium-Magnesium Alloy Plate.** J. Sawkill and D. James. *Brit. Welding J.*, Nov., 1958, pp. 517–522. Description of tests at ambient temperature and at −195°C. to determine the notch sensitivity of plain and welded specimens. Some Charpy and tensile tests were also made.

**Low Temperature Properties of Welded and Unwelded Al-5% Mg Alloy Plates.** J. E. Tomlinson and D. R. Jackson. *Brit. Welding J.*, Nov., 1958, pp. 499–510. Description of mechanical tests to determine the suitability of the alloy for liquefied-gas tanks.

**Titanium Alloys Developed for Aircraft-Missile Applications.** *Auto. Ind.*, Aug. 15, 1958, p. 65. Evaluation of Crucible C-105VA, Crucible C-115AMoV, and the all-Beta alloys designed to meet the specific requirements of the advanced aircraft and extended-range missile fields.

**Extruded Aluminium Alloys for Low Temperature Service; An Assessment of the Suitability of Two Materials.** R. J. Durham. *Brit. Welding J.*, Nov., 1958, pp. 510–516.

**On the Temperature Dependence of Yield Stress for Aluminium.** W. D. Sylwestrowicz and D. F. Gibbons. *Philos. Mag., 8th Ser.*, Nov., 1958, pp. 1,326, 1,327.

**Strength at Elevated Temperatures of Aluminium and Certain Aluminium Alloys.** N. P. Inglis and E. C. Larke. *Chartered Mech. Engr.*, June, 1958, pp. 256–258. Abridged.

**Titanium—Its Properties and Design Potentials.** H. E. Barkan. *Elec. Mfg.*, Oct., 1958, pp. 100–109, 272–276.

**Titanium and Its Uses.** E. A. Smith. *Aeronautics*, Oct., 1958, p. 33.

**Lower Airframe Weights with Heat-Treated Titanium Alloys.** E. F. Erbin. *Space/Aeronautics*, Dec., 1958, pp. 42–47. Discussion on the advantages, strength improvements, and use of heat-treated titanium alloys.

### Nonmetallic Materials

**Aircraft Timber. II—The Classification of Timbers.** Appendix I—**Sap-Stain in Timber.** Appendix II—**Timber Defects Caused by Insects.** D. W. Richardson. *SLAE J.*, Sept., 1958, pp. 3–16.

**O Zakone Treniia Vysokoelasticheskikh Materialov.** G. M. Bartenev and V. V. Lavrent'ev. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 126–129. In Russian. Determination of laws governing the frictional behavior of highly elastic materials.

**Application of Structural Adhesives in Air Vehicles.** D. L. Grimes. (*NATO AGARD 7th Structures & Materials Panel, Rome, Mar. 24–Apr. 3, 1958.*) *NATO AGARD Rep. 181*, Mar.–Apr., 1958. 28 pp.

**Dielectric Properties of Reinforced Plastics at Elevated Temperatures.** Irving Katz and J. Goldberg. *Elec. Mfg.*, Dec., 1958, pp. 72–78, 274. 36 refs.

**Plastics for Nose Cones.** Irving Gruntfest. *SAE J.*, Nov., 1958, pp. 72, 73. Evaluation of the properties of plastic materials used for nose cones and other parts of hypersonic vehicles due to their slow decomposition.

**Structural Air.** *Mach. Des.*, Nov. 27, 1958, pp. 22–25. Applications of inflatable rubberized fabric as shelter, aircraft, and boat material.

### Testing Methods

**Elastic Constant—Internal Friction Spectrometer.** D. O. Thompson and F. M. Glass. *Rev. Sci. Instr.*, Nov., 1958, pp. 1,034–1,040. Description of a spectrometer which has been developed for measurements lasting over extended periods of time, as well as for measurements which require a high degree of resolution.

**How to Simplify Tests for Primary Creep Data.** B. B. Muvdi and C. J. Giemza. *SAE J.*, Aug., 1958, pp. 46–48. Description of tests on aluminum, stainless steel, and titanium to determine primary creep at a given temperature.

**Material Testing by Means of Betatron X-Rays.** R. Wideroee. (*VDI Zeitschrift*, vol. 96, 1954, pp. 450–456.) *Gt. Brit., MOS TIL/T4575*, Feb., 1958. 15 pp. 11 refs. Translation.

## Mathematics

**Some Enumerative Formulae for Algebraic Curves.** I. G. Macdonald. *Cambridge Philos. Soc. Proc.*, Oct., 1958, pp. 399–416.

**Ob Ispol'zovanii Privedennogo Koeffitsienta Sherokhovatosti pri Raschete Krivykh Svobodnoi Poverkhnosti Nomograficheskim Metodom.** G. S. Khovanskii. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 112–116. In Russian. Extension of the nomograph method for applying a given roughness coefficient to the calculation of free-surface curves.

**Determination of Upper and Lower Bounds for Solutions to Linear Differential Equations.** R. M. Durstine and D. H. Shaffer. *Quart. Appl. Math.*, Oct., 1958, pp. 315–317.

**Zadacha Dirikhle dlia Odnogo Klassa Lineinykh Ellipticheskikh Uravnenii Vtorogo Poriadka s Parabolicheskim Vyrozhdeniem na Granitse Oblasti.** Khou Chun'-i. *Sci. Rec.*, Aug., 1958, pp. 244–249. In Russian. Analysis of the Dirichlet problem for a class of second-order linear elliptic equations with parabolic degeneration on the domain boundary.

**Some New Techniques in the Dynamic Programming Solution of Variational Problems.** Richard Bellman. *Quart. Appl. Math.*, Oct., 1958, pp. 295–305. 12 refs. Discussion of a method of solution for a class of problems in which the underlying equations and criterion function are linear, although the restraints on the forcing functions may be nonlinear.

**Perekhod ot Lineinogo Differentsial'nogo Uravneniia s Polinomial'nymi Koeffitsientami k Integral'nomu Uravneniiu pri Pomoshchi Operatsionnogo Ischisleniia.** V. V. Karamyshkin. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 553, 554. In Russian. Analysis covering the transition from a linear differential equation with polynomial coefficients to the integral equation by means of operational calculus.

**Asupra Relaţiilor ce Interced Intre Diferite Tipuri de Problem pe Contur Pentru Unele Clase de Ecuaţii cu Derivatie Parţiale e Ordin Superior.** D. Mangeron. *Iaşi Politeh. Inst. Bul.*, Fasc. 1–2, 1957, pp. 39–42. In Rumanian, with summaries in English and Russian. Derivation of the relationship between the solutions of certain boundary value problems.

**On the Stabilization of Matrices and the Convergence of Linear Iterative Processes.** M. E. Fisher and A. T. Fuller. *Cambridge Philos. Soc. Proc.*, Oct., 1958, pp. 417–425.

**O Preobrazovanii Izometrichnykh Poverkhnostei.** A. V. Pogorelov. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 20, 21. In Russian. Development of a method for the transformation of isometric surfaces.

**Generalizarea unor Polinoame de Interpolare Pentru Funcţiile de Mai Variabile.** D. D. Stancu. *Iaşi Politeh. Inst. Bul.*, Fasc. 1–2, 1957, pp. 31–38. In Rumanian, with summaries in English and Russian. Generalization of certain interpolation formulas for functions with many variables.

**The Prediction of a Random Function, Given Simultaneous Values of Its First Few Derivatives.** D. E. Cartwright. *J. Math. & Phys.*, Oct., 1958, pp. 229–245.

**Toroidal Wave Functions.** V. H. Weston. *Quart. Appl. Math.*, Oct., 1958, pp. 237–257. Solution of the Helmholtz equation in toroidal coordinates. A complete set of solutions is obtained representing radiations from a ring source.

**Determination of Stability by Linear Approximation of a Periodic Solution of a System of Differential Equations with Discontinuous Right-Hand Sides.** M. A. Aizerman and F. R. Gantmacher. *Quart. J. Mech. & Appl. Math.*, Nov., 1958, pp. 385–398.

**Asimptoticheskoe Povedenie Reshenii Differentsial'nykh Uravnenii s Malym Parametrom, Sistemy "Bystrykh Dvizhenii" Kotorykh Blizki k Gamil'tonovym.** G. S. Makaeva. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 973–976. In Russian. Determination of the asymptotic behavior of solutions for differential equations with a small parameter having nearly Hamiltonian systems of "rapid motions."

**Über die approximative Lösung von linearen partiellen Differentialgleichungen mit Hilfe von Differenzengleichungen.** Heinz-Otto Kreiss. *KTH Trans. 128*, 1958. 19 pp. In German. Derivation of an approximate solution for linear partial differential equations by means of difference equations.

**On the Solution of Certain Differential Equations by Characteristic Function Expansions.** Tse-Sun Chow. *Quart. Appl. Math.*, Oct., 1958, pp. 227–235.

**Asimptoticheskoe Raziozhenie Reshenii Obyknovennykh Differentsial'nykh Uravnenii Vtorogo Poriadka v Banakhovykh Prostranstvakh.** L. A.

**APRIL 1959!**

*the Space Flight Issue of Aero/Space Engineering*

# A Milestone in Space Literature

reaching those who "Count" and "Buy" in the AERO/SPACE INDUSTRY

NO INCREASE IN RATES
CLOSING DATE MAR. 1

***Featuring such authors as:***

H. Guyford Stever, Associate Dean of Engineering, Massachusetts Institute of Technology.

C. J. Mundo, Technical Staff Consultant, Arma Division, American Bosch Arma Corp.

Robert H. Boden, Project Engineer—Advance Design, Rocketdyne Division, North American Aviation, Inc.

Jack N. Nielsen, Partner, Vidya Associates.

Richard H. Parvin, Senior Systems Engineer, Aeronautical Division, Minneapolis-Honeywell Regulator Company.

Earl A. Kops, Assistant Design Group Engineer, and Hugo F. Mohrlock, Design Group Engineer, Convair (San Diego) Division, General Dynamics Corp.

Harry Esses, Senior Engineer, Wright Aeronautical Division, Curtiss-Wright Corp.

Louis N. Ridenour, Chief Scientist, Missile Systems Division, Lockheed Aircraft Corp.

Clayton C. Clark, Weapon System Representative, North American Aviation, Inc.

Edgar Schmued, Consultant, (formerly of Northrop Aircraft, Inc.)

..... and others!

***Featuring such subjects as:***

Satellite Landing Problems

Electronics in Space

Technical Management—From Airplanes to Space Vehicles

Organizing to Explore the Moon and Planets

Shape and Space Motions of the Earth

Space Flight in the X-15

Satellite Orbit Mechanics

Ion Rocket Engine Systems—A Summary

Crew Escape and Survival Means in Space Vehicles

Trade-Off Considerations in Space Guidance

..... and others!

*Again - A/SE is ahead - Again*

Groza. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 963–966. 12 refs. In Russian. Asymptotic expansion of solutions of ordinary second-order differential equations in Banach spaces.

**Ob Ogranichennosti i Ustoichivosti v Tselom Reshenii Nekotorykh Nelineinykh Differentsial'nykh Uravenii.** V. A. Iakubovich. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 984–986. In Russian. Determination of the boundedness and stability in the whole of solutions for some nonlinear differential equations.

**On Some Iterative Methods for Solving Elliptic Difference Equations.** H. B. Keller. *Quart. Appl. Math.*, Oct., 1958, pp. 209–226. Formulation of a family of iterative schemes for a particular class of coefficient matrices. This family is defined by a generalization of the usual motion of extrapolation or over-relaxation. It is then possible to formulate the problem of finding the best scheme, and some general theorems on the eigenvalues of the schemes are proved.

**On the Numerical Solution of n-Dimensional Boundary Value Problems Associated with Poisson's Equation.** Donald Greenspan. *Franklin Inst. J.*, Nov., 1958, pp. 365–372. 18 refs.

**Über sachgemässe Cauchyprobleme für Systeme von linearen partiellen Differentialgleichungen.** Heinz-Otto Kreiss. *KTH Trans. 127*, 1958. 27 pp. In German. Analysis to determine the conditions under which the Cauchy problem for general systems of partial differential equations with $t$-dependent coefficients becomes relevant.

**A Note on Numerical Solution of Certain Linear Boundary Value Problems.** R. W. Cole. *Assoc. Comp. Mach. J.*, July, 1958, pp. 258–260.

**O Zavisimosti Indeksa Odnogo Operatora Granichnoi Zadachi dlia Ellipticheskoi Sistemy Lineinykh Differentsial'nykh Uravnenii Vtorogo Poriadka ot Starshikh Koeffizsientov.** B. R. Lavriuk. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 970–972. In Russian. Analysis covering the index of the operator in a boundary problem for an elliptical system of second-order linear differential equations in order to determine its dependence on the highest coefficients.

**The Method of Approximate Separation of Variables and Its Application to Boundary Value Problems of Electrodynamics and Acoustics.** L. A. Vainshtein. *Sov. Phys.-Tech. Phys.*, Sept., 1957, pp. 1,955–1,973. 10 refs. Translation.

**Funktsii Analiticheskie Otnositel'no Giperbolicheskogo Operatora s Dvumia Nezavisimymi Peremennymi.** V. G. Khriptun. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 26–28. In Russian. Evaluation of functions which are analytical in respect to a hyperbolic operator involving two independent variables.

**O Sviazi Metoda Blizkikh Sistem v Spetsial'nykh Lineinykh Topologicheskikh Prostranstvakh s Nekotorymi Voprosami Teorii Vozmushcheniia Lineinykh Operatorov v Banakhovykh Prostranstvakh.** K. M. Fishman. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 22–25. In Russian. Analysis of the relationship between the method of close systems in special linear topological spaces and certain problems in the theory of perturbation of linear operators in Banach spaces.

**K Voprosu ob Ekstremal'nykh Funktsiiakh v Nekotorykh Zadachakh Teorii Priblizheniia.** S. I. Rabinovich. *AN SSSR Dokl.*, Aug. 21, 1958, pp. 977–979. In Russian. Evaluation of extremum functions in some problems of the approximation theory.

**Ob Asimptoticheskom Povedenii Analiticheskikh Funktsii.** A. V. Lototskii. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 17–19. In Russian. Determination of the asymptotic behavior of analytic functions.

**The Approximate Solution of Matrix Problems.** A. S. Householder. *Assoc. Comp. Mach. J.*, July, 1958, pp. 205–243. 28 refs. Development of methods of obtaining and methods of appraising approximate solutions of matrix problems.

**On Modern Matrix Iteration Processes of Bernoulli and Graeffe Type.** F. L. Bauer. *Assoc. Comp. Mach. J.*, July, 1958, pp. 246–257. 24 refs. ONR-sponsored analysis.

## Mechanics

**Subharmonics of Any Order in Nonlinear Systems of One Degree of Freedom: Application to Subharmonics of Order 1/3.** D. G. Magiros. *Info. & Control*, Sept., 1958, pp. 198–227. 21 refs.

**Co-Ordinates Which Uncouple the Equations of Motion of Damped Linear Dynamic Systems.** K. A. Foss. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–86.*) *J. Appl. Mech.*, Sept., 1958, pp. 361–364. ONR-sponsored derivation of orthogonality relations between the eigenvectors of damped linear dynamic systems with lumped parameters. From these relations coordinates are found in terms of which uncoupled equations of motion can be written.

**Vozdeistvie na Nelineinye Kolebatel'nye Sistemy Vneshnikh Sil s Peremennymi Chastotami.** Iu. A. Mitropol'skii. *Iasi Politeh. Inst. Bul.*, Fasc. 1–2, 1957, pp. 15–24. In Russian, with summaries in French and Rumanian. Study of the problem covering the effect of external variable-frequency forces on nonlinear vibrating systems with one or more degrees of freedom.

**Nelineinoe Gashenie Sobstvennykh Kolebani. Sistem Proizvolnogo Poriadka.** V. V. Laricheva. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 536–541. In Russian. Determination of the nonlinear damping of natural vibrations in arbitrary systems.

**O Kvazigarmonicheskikh Sistemakh, Blizkikh k Sistemam s Postoiannymi Koeffitsientami, u Kotorykh Chisto Mnimye Korni Fundamental'nogo Uravneniia Imeiut Neprostye Elementarnye Deliteli.** M. Ia. Kushul'. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 519–533. In Russian. Study of quasi-harmonic systems, similar to those with constant coefficients, whose purely imaginary roots of the basic equation have nonsimple elementary dividers.

**Postroenie Periodicheskikh Reshenii Avtonomnykh Sistem s Odnoi Stepen'iu Svobody v Sluchae Proizvol'nykh Veshchestvennykh Kornei Uravneniia Osnovnykh Amplitud.** A. P. Proskuriakov. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 510–518. In Russian. Derivation of periodic solutions for systems with one degree of freedom in the case of random roots of the basic amplitude equation.

**O Prodolzhenii Optiko-Mekhanicheskoi Analogii.** N. G. Chetaev. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 487–489. In Russian. Establishment of an analogy between the mathematical theory of light developed by Cauchy and the steady motion of conservative mechanical systems.

**Über die Änderung von Dämpfung und Frequenz eines schwingungsfähigen Systems bei Änderung der Koeffizieaten der Systemmatrix.** R. Ludwig. *DFL Inst. Flugmech. Bericht No. 99*, June 23, 1958. 17 pp. In German. Derivation of a system of equations to determine the effect of changes in the coefficients of the matrix on damping and frequency of an oscillating system.

**O Parametricheskom Rezonanse Drobnogo Poriadka.** V. O. Kononenko. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 62–65. In Russian. Study of resonance phenomena in vibrating systems whose motion is described by differential equations with almost periodic coefficients.

**O Razvetvlenii Ustoichivykh Polozhenii Dinamicheskogo Ravnovesiia Odnoi Mekhanicheskoi Sistemy.** A. Iu. Ishlinskii, S. V. Malashenko, and M. E. Temchenko. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 53–61. In Russian. Study to determine the types of dynamic stability found in a mechanical system.

## Meteorology

**Meteorology for Jet Aircraft.** K. R. Saha. *Indian AF Quart.*, Oct.-Dec., 1957, pp. 1–8. Discussion of high-altitude meteorological requirements and the need for further study and research.

**Starkwindschichten in der Stratosphäre?** Heinrich Faust. *Raketentech. & Raumfahrtforsch.*, Oct., 1958, pp. 117–120. 16 refs. In German. Study covering the existence of a strong wind layer in the higher atmosphere which is of interest in the trajectory determination for long-range missiles.

**Radio-Astronomy and Navigation.** Appendix I—**Astrophysical Data and Physical Constants.** Appendix II—**The Possible Effects on Terrestrial Communications of a Close Supernova.** C. M. Cade. *RAeS J.*, Nov., 1958, pp. 805–828. 269 refs. Outline of the history and present state of knowledge of radio astronomy. The stronger localized radio sources are treated, and the ways of using them as navigational aids are considered. Experiments made with 8.6 mm. solar radiation are described.

**II—Recent Literature on Radar Meteorology.** *Meteor. Abs. & Bibliog.*, Aug., 1958, pp. 1,005–1,030. 130 refs.

**On the Correlation Fields and the Predicting Possibilities by Statistical Methods at 500 mb Level.** M. Magata, T. Ozawa, E. Suzuki, T. Fujita, and K. Tomatsu. *Papers in Meteorology & Geophys.*, Jan., 1958, pp. 245–270.

**Osnovnye Tipy Dvizhenii Baroklinnoi Atmosfery v Pole Sily Koriolisa.** A. S. Monin and A. M. Obukhov. *AN SSSR Dokl.*, Sept. 1, 1958, pp. 58–61. In Russian. Determination of basic types of baroclinic atmospheric motions in the field of Coriolis force.

## Missiles, Rockets

**Full-Scale Experimentation with Guided Weapons.** A. R. Weyl. *Aeronautics*, Sept., 1958, pp. 164–177 (ff.). Discussion including site testing, telemetry, tracking methods, and the rise of rockets for geophysical research.

**Systems Checkout Insures Missile Reliability.** M. A. Stephens. *SAE J.*, Aug., 1958, pp. 80, 81.

**Why the Falcon is Easy to Maintain in the Field.** R. W. Manley. *SAE J.*, Oct., 1958, pp. 26, 27.

**Etudes et Essais d'Engins Sol-Sol à Combustible Liquide et à Trajectoire Quasi Rectiligne.** Claudio Belmundo. (*A.E.R.A. Internatl. Congr. Rockets & Guided Missiles, Paris, Dec. 3–8, 1956.*) *Fusées*, July, 1958, pp. 65–68. In French. Description of studies and tests on ground-to-ground missiles with liquid propellant and a quasi-linear trajectory.

**Hydrofusées pour Propulsion Sous-Marine.** Glauco Partel. (*A.E.R.A. Internatl. Congr. Rockets & Guided Missiles, Paris, Dec. 3–8, 1956.*) *Fusées*, July 1958, pp. 59–64. In French. Description of investigations on hydrorockets for underwater propulsion.

**A Catalogue of British Guided Weapons.** *Aeronautics*, Sept., 1958, pp. 92, 93.

**Characteristics and Stabilization of an Inertial Platform.** T. Mitsutomi. (*IRE 3rd Annual East Coast Conf., Aero. & Nav. Electronics, Baltimore, Oct. 29, 1956.*) *IRE Trans., ANE Ser.*, June, 1958, pp. 95–105. Analysis of a stable platform system using a single-axis basis. The single-axis analysis then is made applicable to the three-axis case by introducing a coupling factor. The disadvantages of such an analysis are discussed together with the need for an improved transistorized amplifier.

**Das Grob-Fein-Leitstrahl-Steuerungssystem.** G. Guanella. *Raketentech. & Raumfahrtforsch.*, Oct., 1958, pp. 109–116. In German. Discussion of a beam-guidance system developed for ground-to-air missiles. Includes description of special antennas, covering the radio transmitter and receiver instrumentation used.

**Special Issue: Testing, Handling, and Launching.** *Astronautics*, Dec., 1958, pp. 18–43, 52, 53, 62–70, 76–78, 84–89, 96–101, 107. *Partial Contents:* Experimental Missile Firings—A Functional Analysis, K. H. Debus. Atlas Handling from Factory to Launch, Ch. J. Dunn. ICBM Launch Control, J. E. Gallo. Moon Probe Launch: What it Takes. Support Systems for Liquid Engines, Powel Brown. AF Logistics for Ballistic Missiles, H. G. Macdonald. Toward Universal Missile Test Systems, Robert Gray. GSE Design Criteria, L. W. Schopp and C. E. Fordham. Early Testing Means Better Ground Support Equipment, Charles Johnson. Corrosion Prevention for Polaris, H. C. Slaughter. The Polaris Launching System, D. K. Ela. ASM Handling and Launching, K. L. Levin and David Feld.

**Final Performance Testing of a Large Guided Missile.** R. L. Smith, Jr. *Elec. Mfg.*, Dec., 1958, pp. 46–52. Description of test equipment, facilities, and general procedures used in systems checkout and final simulated flight test for the Jupiter missile.

**On the Optimization of Physical Propulsion Systems.** R. R. Newton. *Jet Propulsion*, Nov., 1958, pp. 752, 753. Navy-supported study to determine if there is any choice in exhaust velocity which leads to minimum energy or power, for a fixed value of initial velocity. The analysis is made for two different cases: first with no external force, and second with a constant gravitational field.

**Special Issue: Fluid Power for Missiles and Ground Support Equipment.** *Appl. Hydraulics & Pneumatics*, Sept., 1958, pp. 69–112. *Contents:* Fluid Power—The Muscles for Missiles. Checklist of Hydraulics and Pneumatics on Missiles and Ground Support. Centrifugal Pumps Match Harmonic Flow and Pressure; Design of Ship Motion Simulator to Test Polaris, L. Mollick. Wrap-Around Hydraulics Guides the Talos. Ground Support System for Mace and Matador Missiles. Power Sources for Spaceborne Hydraulics, William Groen. Nike's Servo Valve—How It Controls Roll, J. W. Schaefer. Hot-Gas Pressurized Accumulator. When to Use a Hot Gas Servo, M. R. Hannah. Rocket Launcher Adapts Fire Engine Design, R. H. Edelston and Hubert Walker. Hydraulic Lock for Missile Control Surfaces, E. A. Hilburger. Series-Parallel Hydraulics Helps Launch Missiles, Murray Sackson and Howard Steinberg. Modified Lift Truck Loads Missile Launcher, John Knarr.

## Navigation

**Comparative Evaluation of Several Azimuth Estimating Procedures Using Digital Processing and Search Radar Simulation.** C. M. Walter, J. Atkin, and H. Bickel. *IRE Trans., ANE Ser.*, June, 1958, pp. 114–121.

**Fundamentals of Inertial Guidance and Navigation.** W. E. Frye. *J. Astron. Sci.*, Spring, 1958, pp. 1–4, 10. Discussion of some basic concepts of inertial navigation and guidance, including possible applications to space flight and astronautics. The principle of the Schuler pendulum and the fundamentals of accelerometers are described. The mathematical solution for a hypothetical accelerometer system is derived.

**Stellar Inertial Navigation.** R. B. Horsfall. *IRE Trans., ANE Ser.*, June, 1958, pp. 106–114. Discussion of the basic principles and mechanization methods of a system that uses photoelectric telescopes (star trackers) in combination with an inertial system to provide a tie to basic inertial space. Such a system minimizes or eliminates the cumulative effect of inertial drift.

**The Air Traffic Control Paradox.** P. C. Sandretto. *IRE Trans., ANE Ser.*, June, 1958, pp. 80–85. 47 refs. Discussion of the technical and civil problems involved in establishing a complete air traffic control system.

**The Occurrence and Avoidance of Midair Collisions.** S. J. Deitchman. *Aero/Space Engrg.*, Jan., 1959, pp. 53–60. 15 refs. Analysis of

**GITS HH-TYPE SEAL SERIES**

**VITON "A"**

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

# GITS

## *Extra Flexibility For Your Seal Applications!*

## ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

**Use of this one standard Gits HH-type seal envelope—with your choice of the five seal packing arrangements illustrated at left—permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements of the aircraft and missile industry.**

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

## GITS BROS. MFG. CO.

1850C South Kilbourn Avenue • Chicago 23, Illinois

***NEW!*** *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

a simple air traffic model in order to describe the air traffic environment, the nature of the midair collision hazard, and an evaluation of the utility of various airborne devices or systems for collision avoidance.

## Nuclear Energy

**Testing an Aircraft Nuclear Propulsion System.** Herman Miller. *SAE J.*, Nov., 1958, pp. 26–28. Includes details of shop area, radioactive materials laboratory, hot shop equipment, and test procedures.

**Safety Hazards of Nuclear Propulsion.** II. Leo Seren. *Space/Aeronautics*, Dec., 1958, pp. 48–52. Discussion of biological shielding and xenon poisoning as part of a study on the safety aspects of airborne reactor design.

**Radiation Damage.** J. E. Heffernan and J. J. Regazzi. *ARMA Eng.*, May-June, 1958, pp. 5–7. Evaluation covering problems of operation under a high radiation field environment for various materials and equipment.

**Electron Spin Resonance Studies of Radiation Damage to Proteins.** Walter Gordy and Howard Shields. *Duke U. Microwave Lab. Rep. 21 (AFOSR TN 58–353) [AD 154258]*, Feb. 1-May 1, 1958. 20 pp. 15 refs.

**Radiation Damage in Semiconductors.** *Mil. Electronics*, Oct., 1958, pp. 8–10, 13. Description of studies providing means of investigating the fundamental nature of radiation damage and the sensitivity of semiconductors to lattice defects.

**Electronic Equipment vs Nuclear Radiation.** Ch. W. Vrooman. *ARMA Eng.*, May-June, 1958, pp. 8–12. Tentative definition of radiation damage and effects on electronic equipment, including details of the mechanism of interaction, sources of radiation, magnitude of environment, and methods for improving performance under nuclear radiation.

**Effect of High Intensity Radiation on Electronic Parts and Materials.** C. P. Lascaro and A. L. Long. *Elec. Mfg.*, Sept., 1958, pp. 119–121, 306.

**Electron Spin Resonance of Free Radicals in Irradiated Biochemicals.** Walter Gordy. *Duke U. Microwave Lab. Rep. 22 (AFOSR TN 58–729) [AD 162264]*, May 1-Aug. 1, 1958. 30 pp. 24 refs.

**Radiation Damage to Plastics.** D. M. Newell. *SPE J.*, July, 1958, pp. 17–21. Presentation of the results of high dose-rate exposure obtained on several types of plastics, such as Teflon and Plexiglas II. The experimental procedure is described.

**Nuclear Radiation and the Thermal Stability of Jet Fuels.** J. T. Guerin, J. G. Carroll, R. O. Bolt, and J. A. Bert. *Aero/Space Engrg.*, Jan., 1959, pp. 27–31. 11 refs. Test results indicating that at low dosage levels thermal stability is reduced. Above $5 \times 10^8$ roentgens thermal stability is usually unchanged or improved. It is also shown that polymerization caused all the fuels to increase in viscosity with increasing gamma dosage.

## Parachutes

**Extending Capabilities of Escape and Aerial Delivery Systems.** F. B. Stencel. *Aero/Space Engrg.*, Jan., 1959, pp. 47–52. Development of a self-contained power source for the conventional parachute canopy that makes its deployment process independent of airflow conditions.

## Photography

**The Role of Photogrammetry in an "Open Skies" Program.** G. D. Whitmore. *Photogrammetric Eng.*, June, 1958, pp. 376–382.

**Verification of Aerial Photographic Analysis of Urban Residential Structures: A Study of Rochester, New York.** R. B. Monier. *USAF PTRC DR TN 58–4 [AD 152113]*, Jan., 1958. 15 pp.

**High-Speed Framing Disk Camera.** C. H. Bagley. *Rev. Sci. Instr.*, Oct., 1958, pp. 862–864. Development of a high-speed framing camera designed to investigate problems requiring a time coverage from 6 to 20 millisec.

## Physics

**Electromagnetic Structure of the Nucleon.** P. Federbush, M. L. Goldberger, and S. B. Treiman. *Princeton U. Palmer Phys. Lab. Paper (AFOSR TN 58–499) [AD 158309]*, 1958. 68 pp. 27 refs.

**On the Nucleon-Antinucleon Interactions.** M. Gourdin, B. Jancovici, and L. Verlet. *Ecole Normale Supérieure, Lab. Phys. TN 10 (AFOSR TN 58–386) [AD 154293]*, 1958. 16 pp. 15 refs.

**Disturbance Phenomena in Probe Measurement of Ionized Gases.** Takayoshi Okuda and Kenso Yamamoto. *Phys. Soc. Japan J.*, Oct., 1958, pp. 1,212–1,223. Study of disturbance phenomena occurring when a probe is immersed in a plasma. The two types of disturbances, one independent of probe potential and one dependent upon it, are described.

**Antiproton Interactions.** G. A. Ekspong and B. E. Ronne. *Uppsala U. Inst. Phys. TN 1 (AFOSR TN 58–878) [AD 203910]*, 1958. 8 pp.

**Decay Modes and Lifetime of Negative Heavy Mesons.** S. Nilsson and A. Frisk. *Uppsala U. Inst. Phys. TN 3 (AFOSR TN 58–880) [AD 203908]*, 1958. 18 pp. 24 refs.

**Studies on the Mechanism of Electroluminescence.** A. Luyckx, J. Vandewauwer, and S. Ries. *Louvain Cath. U., Lab. Chim. Phys. TN 2 (AFOSR TN 58–875) [AD 203913]*, 1958. 19 pp.

**Thermoluminescence and F Centers. I, II, III.** Guido Bonfiglioli, Piero Brovetto, and Cesare Cortese. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 1b; TN 2b; TN 3b (AFOSR TN 58–355; TN 58–356; TN 58–357) [AD 154260; 154261; 154262]*, 1958. 12; 14; 13 pp. 10 refs.

**Brightness, Width and Position of Mach Bands as a Function of the Rate of Variation of the Luminance Gradient.** Adriana Fiorentini and Tilde Radici. *(Fond. Giorgio Ronchi, Atti*, Mar.-Apr., 1958, pp. 145–155.) *Inst. Nas. Ottica, No. 820 (AFOSR TN 58-676) [AD 162208]*, 1958. 12 pp. Reprint.

**Some Methods for Studying Wave-Propagation in a Uniform Magneto-Ionic Medium.** V. A. Bailey. *J. Atmos. & Terrestrial Phys.*, Nos. 2/3, 1958, pp. 118–125.

**Precision Measurements of Millimeter and Submillimeter Wave Spectra: DCl, DBr, and DI.** Monroe Cowan and Walter Gordy. *Duke U. Microwave Lab. Rep. 22 (AFOSR TN 58-351) [AD 154256]*, May 1-Aug. 1, 1958. 11 pp. 11 refs.

**The Distance Attenuation of Radio Waves Reflected at Vertical Incidence from the Ionosphere.** J. D. Whitehead. *J. Atmos. & Terrestrial Phys.*, Nos. 2/3, 1958, pp. 150–152. Analysis showing the occurrence of errors in the measurement of the reflection coefficient of the ionosphere and of the collision frequency of electrons in the *F*-region.

**Low-Frequency Reflection in the Ionosphere. I.** Hermann Poeverlein. *J. Atmos. & Terrestrial Phys.*, Nos. 2/3, 1958, pp. 126–139. 14 refs. Development of a theory on low-frequency, thin-sheet reflection in the ionosphere; the general theory is also considered.

**The Flux of Cosmic Ray Particles with $Z \geq 2$ Over Texas.** A. Engler, M. F. Kaplon, and J. Klarmann. *Rochester U. Dept. Phys. & Astron. Paper*, 1958. 33 pp. 36 refs. AFOSR-supported research.

**Some Considerations on the Analysis of Primary Cosmic Ray Intensity Experiments.** A. Engler, M. F. Kaplon, and J. Klarmann. *Rochester U. Dept. Phys. & Astron. Paper*, 1958. 34 pp. 22 refs. AFOSR-supported research.

**A Molecular-Orbital Treatment of Isotropic Hyperfine Interactions in Simple Aliphatic Radicals.** D. B. Chesnut. *Duke U. Microwave Lab. Rep. 21 (AFOSR TN 58–352) [AD 154257]*, Feb. 1-May 1, 1958. 17 pp. 15 refs.

**On the Bound State Problem in Quantum Field Theory.** W. Zimmermann. *USAF OSR TN 58–764 [AD 201863]*, 1958. 24 pp. Analysis of a casual and invariant scalar field involving a stable bound state. A formula for the S-matrix is derived and it is shown that the bound state can be described by a local and invariant field operator.

**K – Interactions in Flight.** A. Frisk and S. Nilsson. *Uppsala U. Inst. Phys. TN 2 (AFOSR TN 58–879) [AD 203909]*, 1958. 6 pp.

**An S-Band Ferrite Isolator for Use with a Linear Accelerator.** *USAF OSR TN 1 (TN 58–654) [AD 162185]*, 1958. 4 pp.

**Simultaneous Contrast Effect Produced by Non-Uniform Coloured Fields.** A. M. E. Guzzoni and Adriana Fiorentini. *(Fond. Giorgio Ronchi, Atti*, Mar.-Apr., 1958, pp. 135–144.) *Inst. Naz. Ottica, No. 819 (AFOSR TN 58–675) [AD 162-207]*, 1958. 12 pp. 14 refs. Reprint.

**A Generalized Variational Principle for Transport Phenomena.** G. E. Tauber. *Can. J. Phys.*, Oct., 1958, pp. 1,308–1,318. 18 refs. Formulation of a generalized variational principle which takes the phonon distribution functions and the external magnetic field into account, is valid for an arbitrary direction of the electric field and polarization of the lattice vibrations, and does not depend on any special form of the energy surfaces. The various transport coefficients, for both thermoelectric and thermomagnetic phenomena, are obtained.

**Sovremennaia Teoriia Sverkhprovodimosti.** A. Abrikosov and I. Khalatnikov. *Uspekhi Fiz. Nauk*, Aug., 1958, pp. 551–591. 22 refs. In Russian. Application of a previously derived method to the development of the theory of superconductivity. Includes presentation of experimental results.

**The Effect of Diffusion on the Vertical Distribution of Ionization in a Quiet *F*-Region.** V. C. A. Ferraro and I. Özdoğan. *J. Atmos. & Terrestrial Phys.*, Nos. 2/3, 1958, pp. 140–149.

**Notes on Nuclear Quadrupole Resonance in Solids.** J. Duchesne. *Liege U. Inst. Astrophys. TSN 1 (AFOSR TN 58–815) [AD 202638]*, 1958. 31 pp. 27 refs.

**Investigations of Fast Protolysis Reactions by the Nuclear Magnetic Resonance Technique.** Appendix—**A Modified Spin-Echo Method for Measuring Nuclear Relaxation Times.** S. Meiboom and D. Gill. *Weismann Inst. Sci. Final TR (AFOSR TR 58–110) [AD 201858]*, July, 1958. 70 pp.

**The Theory of Diffusion in Strained Systems.** L. A. Girifalco and H. H. Grimes. *U. S., NACA TN 4408*, Sept., 1958. 49 pp. 26 refs. Development of a general theory of solid-state diffusion on a molecular-kinetic basis. The obtained results are in good agreement with available data.

**Convection Free Instrument for Measuring Infrared Radiation in the Atmosphere.** R. L. Aagard. *Rev. Sci. Instr.*, Nov., 1958, pp. 1,011–1,016. Army-Navy-supported research.

**Studies of Positron Lifetimes in Solids.** A. P. French and A. R. Lowrey. *So. C. U. Rep. (AFOSR TR 58–63) [AD 158241]*, Apr., 1958. 55 pp. 20 refs.

**Near Infrared Solar Radiation Measurements by Balloon to an Altitude of 100,000 Feet.** D. M. Gates, D. G. Murcray, C. C. Shaw, and R. J. Herbold. *OSA J.*, Dec., 1958, pp. 1,010–1,016. USAF-sponsored research.

**Theoretical Analysis of Ultrahigh Vacuum Condensers.** W. R. Mickelsen and J. H. Childs. *Rev. Sci. Instr.*, Oct., 1958, pp. 871–873. Analysis considering the condensation of high-velocity molecular beams on condenser surfaces having very low temperatures. The condenser surface area and volume necessary to maintain a given vacuum are derived theoretically from a highly idealized model.

**Behavior of Lead Sulfide Photocells in the Ultraviolet.** Abbott Smith and David Dutton. *OSA J.*, Dec., 1958, pp. 1,007–1,009. 17 refs. AFOSR-supported research.

**Germanium Standard Wavelengths in the Vacuum Ultraviolet.** K. W. Meissner, R. D. Van Veld, and P. G. Wilkinson. *OSA J.*, Dec., 1958, pp. 1,001–1,006. 14 refs. USAF-Army-supported research.

## Power Plants

**Gas Turbine Progress.** R. T. Sawyer. *Mech. Eng.*, Nov., 1958, pp. 102–110. Discussion on the development and applications of the gas turbine. Its progress realized in the various locomotion fields is described.

**The Design and Development of Engines for High-Speed Flight.** E. S. Moult. *(IME Annual Lecture, London, Mar. 15, 1958.) de Havilland Gazette*, June, 1958, pp. 98–103. Abridged. Includes details of the development process, component development, the choice of speed range, jet propulsion, air-breathing engines, design parameters of the turbojet, the ram-jet, the rocket, the choice of propellants, and mixed power plants.

**Fundamental Investigation of Electrical Power Sources for Electric Thrust Devices—Bibliography.** Helen Fife. *Plasmadyne Corp. TN E-2TN 098-332 (AFOSR TN 58–791) [AD 202-224]*, Sept. 3, 1958. 38 pp. 379 refs.

**The Ion Rocket Engine a Likely Power Source for That Trip to Mars.** D. L. Eschner. *SAE J.*, Aug., 1958, pp. 30–32. Abridged. Includes discussion of primary power source, problem of control, ion generation, and thrust unit development.

### *Jet & Turbine*

**Theoretische Berechnung des By-Pass-Triebwerkes. II—Überschall-Bereich.** O. Lutz and W. Dietze. *DFL Inst. Strahltriebwerke Bericht No. 82*, June, 1958. 36 pp. 12 refs. In German. Theoretical calculation of the by-pass engine for the supersonic regime compared to the pure jet. Such factors as specific thrust, combustion chamber temperature, and Mach Number are considered.

**Static Bending of Pre-Twisted Cantilever Blading.** William Carnegie. *IME Proc.*, No. 32, 1957, pp. 873–886; Communications, pp. 887–890; Author's Reply, pp. 891–894. Study of the bending of blades having pre-twist angles not greater than $\pi/2$ radians, and establishment of expressions for the lateral deflections.

**Effect of Fuel Variables on Carbon Formation in Turbojet-Engine Combustors.** E. R. Jonash, J. D. Wear, and W. P. Cook. *U.S., NACA Rep. 1352*, 1958. 18 pp. 12 refs. Supt. of Doc., Wash., $0.25.

**The Performance and Reliability of Aero-Gas-Turbine Combustion Chambers.** J. S. Clarke and H. E. Lardge. *(ASME Gas Turbine Power Conf., Wash., Mar. 2–6, 1958, Paper 58–GTP-13.) ASME Trans.*, Nov., 1958, pp. 1,741–1,755. Study of the range of running conditions with special reference to the factors affecting the life and reliability of the chamber. An evaluation of materials and design is made.

**200 to 200,000,000 Decisions Are Needed to Design a Jet Engine Control System.** A. J. Sobey. *SAE J.*, Aug., 1958, pp. 90, 91.

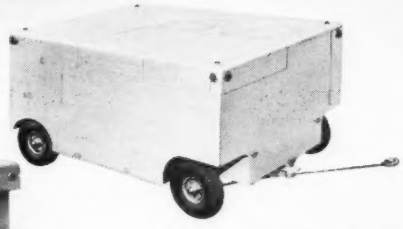
**Britain's Aero Engines.** *Aeronautics*, Sept., 1958, pp. 94–104.

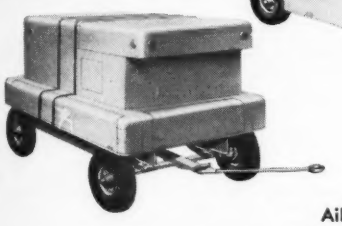
**Shaft Turbines by Lycoming.** *The Aeroplane*, Oct. 10, 1958, pp. 559–561. Description of the design, development, application, and performance of Lycoming's T-53 and T-55 power plants.

**Erosion in Turbojet Fuel Nozzles.** H. R. Hazard, P. Gluck, and R. W. Tate. *(ASME Semi-Annual Meeting, Detroit, June 15–19, 1958, Paper 58—SA-55.) Mech. Eng.*, Oct., 1958, pp.

Truck installations supply pneumatic power for main engine starting, cooling and heating, electrical power for commercial jet powered airliners.

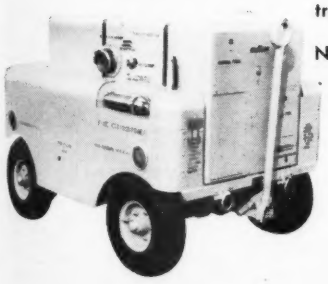
Dual carts for main engine starting, air conditioning and electrical power for military aircraft.



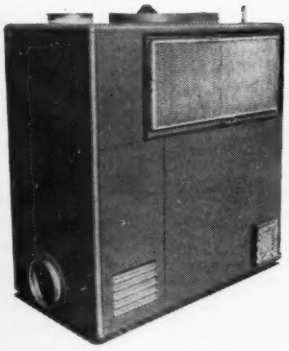


# Reliable and versatile ground support

AiResearch MA-1A trailer for starting military aircraft. Nearly 2,500 in the field.



Air transportable pod for engine starting, cooling of electronic equipment and pre-flight checkout for military aircraft.



Lightweight Freon system, usually installed in a van or trailer, for cooling electronic equipment in support of missiles.

***AiResearch ground support equipment is tailored to meet turbine powered aircraft and tactical missile requirements. Lightweight, compact units can be designed to specific configurations or installed on standard vehicles.***

Heart of the lightweight ground support systems are AiResearch gas turbine compressor power units. Capable of delivering both electrical and pneumatic power, nearly 8,000 of these units are operating successfully and dependably in the field.

Support services can include: main engine starting, pressurization and air conditioning of cabins and compartments, missile pre-flight check-out, removal of snow and ice from aircraft and equipment, supply of DC or AC electrical power at any required frequency, and low pressure, high flow air for operation of a variety of actuation systems. The units have push-button starting and operate without delay under all weather conditions.

The world's largest producer of lightweight turbomachinery, the AiResearch Manufacturing Divisions are prepared to assume complete systems management responsibility for your ground support requirements.

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

*Los Angeles 45, California • Phoenix, Arizona*

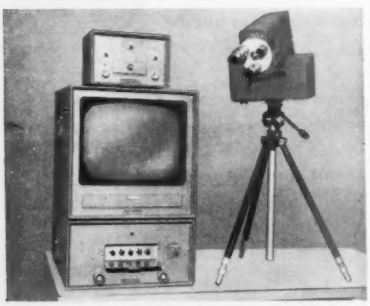
*Systems, Packages and Components for:* AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

ITT

# What's New in ITV

Many exciting new uses for closed circuit television save time, life, health and money for industry, military, education and business.

- In the Antarctic, the Navy uses CCTV on a helicopter to picture ice conditions to an ice breaker following.
- A utility using ITV to observe water levels saved three salaries.
- In handling freight, ITV inspected cars and gondolas from a distance.
- Watching oil drilling or diving operations on the ocean floor from the surface.
- Checking factory operations for floors above from the main floor saved time and money.
- Guiding bulldozers run automatically in radioactivity areas from a safe distance.
- Stores and markets cut shoplifting and pilferage with ITV.
- Flame patterns in combustion chambers of engines and boilers may now be observed.
- Large organizations reach dealers through ITV in many cities for simultaneous meetings.
- Traffic flow through tunnels or toll bridges is checked and controlled.
- TV camera on factory roof scans large roofs for fires.



**ITT makes a complete and versatile line of closed circuit TV for every military, industrial, business and educational requirement. For bulletins, engineering data and other information call our nearest office.**

Los Angeles, Calif. .... EMpire 7-6161
Detroit, Mich. ..... JEfferson 6-4040
Fort Myers, Fla. ... WYandotte 5-2151
Washington, D.C. ..... EMpire 5-1515
Denver, Colo. .. .... AMherst 6-2714
New York City ..... OXford 5-0082
San Carlos, Calif. ..... LYtell 3-2189
Ft. Worth, Tex. . .. JEfferson 5-2056

*Industrial Products Division*

International Telephone and Telegraph Corp.
15191 Bledsoe St., San Fernando, California

**Closed Circuit TV • Custom Power Equipment**
**Infra Red Equipment • Large Screen Oscilloscopes**
**Electronic Instruments • Autopilots for Aircraft**

59, 60. Discussion of an erosion study in which a laboratory procedure for simulating engine conditions is developed and a radio-chemical technique is perfected for measuring erosion of a few millionths of a gram of material in a few hours.

**Characteristic Velocity as a Measure of Available Work.** S. L. Bragg and H. Ratcliffe. *Jet Propulsion*, Nov., 1958, p. 762. Study showing that the power available from a gas turbine is dependent primarily on the characteristic velocity of the entering gas and is otherwise insensitive to gas properties, such as the specific heat ratio.

**New Explosive-Mixture Detector Safeguards Engine Tests.** R. E. Gorton and G. J. Lyons. *ISA J.*, Aug., 1958, pp. 31–35. Description of a more accurate and dependable automatic lower-explosive-limit detector (LEL) used in gas turbine testing.

**Thrust Reversal for the Comets.** F. I. Marking. *de Havilland Gazette*, Oct., 1958, pp. 178–180. Survey of the development of thrust reversal and description of equipment used, including such factors as injestion, operation and control, performance, and safety.

### *Reciprocating*

**Issledovanie Turbulentnosti v Tsilindre Porshnevogo Dvigatelia.** E. S. Semenov and A. S. Sokolik. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 130–134. In Russian. Study of the turbulent combustion in piston engines.

### *Rocket*

**Moyens de Protection des Matériaux pour Moteurs à Réaction Fonctionnant en Combustion Instable.** B. Langenecker. (*A.E.R.A. Internatl. Congr. Rockets & Guided Missiles, Paris, Dec. 3–8, 1956.*) *Fusées*, July, 1958, pp. 77–85. 24 refs. In French. Presentation of experimental results covering the effect of unstable oscillating combustion on the behavior of metals used for rocket power plants. Includes discussion of means for preventing these phenomena.

**Etude Théorique et Expérimentale d'un Système Propulseur à "Litergol."** R. Corelli. (*A.E.R.A. Internatl. Congr. Rockets & Guided Missiles, Paris, Dec. 3–8, 1956.*) *Fusées*, July, 1958, pp. 69–75. In French. Theoretical and experimental study of a lithergol (liquid/solid) propulsion system, including a survey of the advantages and limitations of liquid and solid systems, discussion of possible fuel combinations, and calculation of specific thrusts.

**Rocket Throttling: Tricky but not Impossible.** K. R. Stehling. *Space/Aeronautics*, Dec., 1958, pp. 66–71. Discussion of the problems and possible methods of rocket throttling.

**Rocket Engines and Nondestructive Testing. II.** R. P. Frohmberg. *Auto Ind.*, Aug. 15, 1958, pp. 68, 118. Includes such factors as knowledge of processing, inadequacy of some tests, and reduced costs.

## Production

**The Redstone: Built in Productibility.** W. R. Studhalter. *Western Av.*, Nov., 1958, pp. 14–20. Discussion of reliability testing and manufacturing techniques used in producing the Redstone engine.

### *Metalworking*

**Three New Ways to Make Precision Forgings, Extrusions.** J. F. Murphy. *Materials in Des. Eng.*, Nov., 1958, pp. 105–107. Discussion of rotary forging, precision gear forging, and cross extrusion methods and their application.

**Fabricating Superalloys.** H. E. Haley. *Tool Engr.*, Nov., 1958, pp. 96–101. Discussion which includes welding, joint design and edge preparation, jigs and fixtures, forming, heat treatment, descaling, and forging.

**B-58 Features Adhesive-Bonded Structures—Why, Where, and How They Are Used.** W. K. Bailey. *SAE J.*, Sept., 1958, pp. 39–41.

**Recent Developments in the Manufacture of Castings.** J. L. Rice, R. W. Ruddle, and P. A. Russell. (*IME General Meeting, London, Nov. 29, 1957.*) *IME Proc.*, No. 4, 1958, pp. 133–151; Discussion, pp. 152–157; Communications, pp. 157, 158; Authors' Replies, pp. 158–160. 87 refs. Discussion of new and established processes, alloy development, inspection, and future trends.

**Precision Hollow Forgings in Non-Ferrous Alloys.** H. D. Challen. *Metal Treat.*, July, 1958, pp. 269–274. Discussion of forging methods developed for $\beta$ brasses, combining features of stamping and extruding.

**The Case for Swaging.** L. A. Whiting. *Prod. Eng.*, Nov. 24, 1958, pp. 70, 71. Discussion of methods for choosing suitable materials and specifying shapes and tolerances.

**Superalloys Formed with Explosives.** P. J. Wolf. *Tool Engr.*, Dec., 1958, pp. 78–86. Description of explosive forming; its advantages and applications are discussed.

**Controlled Atmospheres for Metallurgical Processes. II.** I. L. S. Golding. *Metal Treat.*, July, 1958, pp. 283–297. Survey of present day processes and plant for generating special atmospheres.

**Ultrahigh-Speed Machining—Panacea or Pipedream?** A. O. Schmidt. *Tool Engr.*, Nov., 1958, pp. 105–109. 14 refs. Discussion of test data in metal cutting and related fields which concludes that high-speed machining alone will not cut high-strength alloys used in aircraft construction.

**Power Brushing for Finishing Without Burrs.** *Tool Engr.*, Nov., 1958, pp. 110–112. Application of power brushing to remove stress-raising scratches and tool marks.

**Low Speed Cascade Study of a Simply Generated Compressor Blade Shape.** D. Banerjee and P. Pal. *J. Techn.*, June, 1958, pp. 43–52. 10 refs. Discussion of a simple method for manufacturing compressor blades without the use of special purpose machine tools. Low-speed testing of these blades in a straight cascade has been presented to show the effect of the deviation in the blade shape from the true aerodynamic profile.

**Principles and Applications of Honing Fixtures.** J. H. Greening. *Tool Engr.*, Nov., 1958, pp. 91–95.

**Deep-Hole Drilling with Standard Twist Drills.** Michael Zajac. *Tool. Engr.*, Nov., 1958, pp. 113–115.

**Developments in the Inert-Gas Tungsten-Arc Fusion Spotwelding Process.** F. W. Copleston and L. M. Gourd. *Brit. Welding J.*, Sept., 1958, pp. 394–399.

**Controlled-Atmosphere Arc Welding.** N. E. Weare and R. E. Monroe. (*AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J.*, Dec., 1958, pp. 1,169–1,175. Discussion of some general considerations of controlled-atmosphere arc welding. Open shielding systems and closed chambers are considered.

**High-Current Inert-Gas Metal-Arc Welding of Aluminium.** A. A. Smith and P. T. Houldcroft. *Brit. Welding J.*, Sept., 1958, pp. 421–426.

**Automatic Welding of Aluminium Plate.** J. E. Tomlinson and D. Slater. *Brit. Welding J.*, Aug., 1958, pp. 361–368. Description of tests in which individual variations are studied and the obtained results are used to predict specific welding conditions.

**Some Guidance on Welding Dissimilar Alloy Steels.** M. C. T. Bystram. *Brit. Welding J.*, 1958, pp. 475–480. Review of the problems of welding various grades of ferritic and stainless steels, as well as high-nickel alloys in different combinations, taking into account applications to ambient, sub-zero, and elevated temperatures.

**Manual "Open Air" Welding of Reactive Metals; The Gas Shielding Problem.** J. C. Borland and W. G. Hull. *Brit. Welding J.*, Sept., 1958, pp. 427–434. Examination of factors affecting gas coverage provided by round nozzles and description of the design of such a nozzle for welding titanium sheets.

**Recommendations for the X-Ray Examination of Fusion Welded Joints in Light Alloys.** *Brit. Welding J.*, Nov., 1958, pp. 489–491. Description of radiographic techniques used for inspecting fusion welds in light alloys.

**Properties of Fusion Welds in Unalloyed Titanium and Ti-5% Al-2½% Sn Alloy Sheet.** J. C. Borland and W. G. Hull. *Brit. Welding J.*, Aug., 1958, pp. 374–380. 13 refs.

**Building the New Comets; Expanding Production at Hatfield, Chester and Portsmouth.** *de Havilland Gazette*, June, 1958, pp. 78–81.

### *Nonmetalworking*

**Drape Vacuum Forming is One of Many Ways to Produce Sheet Formed Plastics Parts.** J. C. Merriam. *Materials in Des. Eng.*, Nov., 1958, pp. 121–136.

### *Production Engineering*

**The Application of Diazo Type Materials to Industrial Planning and Engineering.** G. F. Sztuk. *USAF RADC TN 58–250* [*AD 202097*], Oct., 1958. 12 pp.

**Use of Radioisotopes in Filler Metal for Nondestructive Inspection.** P. T. Barnes and G. L. Locher. (*AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J.*, Dec., 1958, pp. 1,176–1,181.

### *Tooling*

**Jigs and Fixtures for Heat Treatment and Other Metallurgical Operations.** L. G. H. Palethorpe. *Metal Treat.*, July, 1958, pp. 275–282.

## Propellers

**The Propeller for the Vickers Vanguard.** *de Havilland Gazette*, Aug., 1958, pp. 112–114. Survey of the latest safety and control features embodied in a propeller designed to absorb the 5,000-s. hp. developed by the Rolls-Royce Tyne turbine engine.

## Research, Research Facilities

**To Beat the "Complexity" Barrier.** J. de S. Coutinho. (*ASME Joint Av. Conf., Dallas,*

(*Continued on page 111*)



XUM

# Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science —who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

*Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:*

**Professional Staff Appointments**

## The Johns Hopkins University Applied Physics Laboratory

8605 Georgia Avenue, Silver Spring, Maryland

# IAS REPORTS

## Twenty-Seventh Annual Meeting, New York, January 26–29, 1959

**IAS MEMBER PRICE—$0.50 NONMEMBER PRICE—$1.00**

**59-1** Hypersonic Viscous Flow Over Slender Cones—L. Talbot, T. Koga and P. M. Sherman

**59-2** The Cone-Sphere in Hypersonic Helium Above Mach Number Twenty—R. H. Johnson

**59-3** A Study of Creep Collapse of a Long Circular Cylindrical Shell Under Uniform External Pressure—N. J. Hoff, W. E. Jahsman, and W. Nachbar

**59-4** On the Base Pressure Resulting from the Interaction of a Supersonic External Stream with a Sonic or Subsonic Jet—Wen-Lung Chow

**59-5** Buckling of a Cylindrical Shell Under a Circumferential Band Load—Don O. Brush and F. A. Field

**59-6** The Spectrum of Vertical Velocity Near the Surface—H. A. Panofsky and R. A. McCormick

**59-7** Piloting Procedures and Some Human Factors Aspects of the VTOL—Transition Cycle of the X-13 Aircraft—P. F. Girard

**59-8** Flight Testing Experiments with the Tilt-Wing Aircraft—W. Z. Stepniewski and P. J. Dancik

**59-9** Proposed Observations of the Martian Atmosphere—M. D. Ross

**59-10** Self-Contained Electric-Hydraulic Accessory Power Unit—R. L. McManus

**59-11** Sources of Helicopter Development and Manufacturing Costs—J. B. Nichols

**59-12** Flight Control-Airframe System Optimization—I. L. Ashkenas and D. T. McRuer

**59-13** The Physicist's Viewpoint: The Function of Universities in the Aero-Space Engineering Education—S. F. Singer

**59-14** Flexural Vibrations of a Thick Walled Circular Cylinder According to the Exact Theory of Elasticity—J. E. Greenspon

**59-15** Industry's Viewpoint on the Challenge of Space Technology to Aeronautical Engineering—G. Merrill

**59-16** An Investigation of Optimal Zoom Climb Techniques—Henry J. Kelley

**59-17** Two Non-Linear Problems in the Flight Dynamics of Modern Ballistic Missiles—J. D. Nicolaides

**59-18** Practical High Lift Systems Using Distributed Boundary Layer Control—J. J. Cornish III

**59-19** Some Considerations Relative to Acoustically Induced Structural Fatigue in a Supersonic Transport Aircraft—G. L. Getline

**59-20** Fail-Safe and Fatigue Development of the Prop-Jet Transport Airplane—A. J. York

**59-21** Thin Doublers for Fatigue Resistant Aluminum Alloy Structures—C. R. Smith

**59-22** Viability Surveillance and Data Collection in Biosatellite Experiments—A. W. Hetherington

**59-23** What Is Specific Impulse Worth?—E. R. Hinz

**59-24** Potentialities and Problems of Nuclear Rocket Propulsion—T. P. Cotter

**59-25** Performance of Nuclear Electric Propulsion Systems—V. P. Kovacik and D. P. Ross

**59-26** Comparison of Current Operational Rotor Systems and a Rotor Having Floating Hub and Offset Coning Hinges—M. D. Marks

**59-27** Helicopter Stabilization and Handling Characteristics Improvement by Mechanical Means—M. Vague and C. M. Seibel

**59-28** Main Rotor Blade Design and Development—R. M. Kee

**59-29** Geophysical Researches with the Stratospheric Laboratory—W. O. Roberts and G. Newkirk, Jr.

**59-30** Guidance Requirements of Ballistic Satellites—M. J. Stateman

**59-31** The Determination of Round-Trip Planetary Reconnaissance Trajectories—R. H. Battin

**59-32** Design of Automatic Flight Control Systems for Manned Space Vehicles—A. J. Kelley

**59-33** Inertial Guidance for Hypersonic and Orbital Vehicles—G. W. Johnson and R. B. MacDonald

**59-34** Wave Propagation Through Ionized Gas in Space Communications—F. J. Tischer

**59-35** A Shock Tube Investigation of Heat Transfer in the Wave of a Hemisphere-Cylinder, with Application to Hypersonic Flight—W. E. Powers, K. F. Stetson and Mac C. Adams

**59-36** Boundary Layer Transition on Blunt Bodies with Highly Cooled Boundary Layers—K. F. Stetson

**59-37** Heat Transfer in Separated Flows—H. K. Larson

**59-38** Experiments on Porous-Wall Cooling and Flow Separation Control in a Supersonic Nozzle—L. Green, Jr., and K. L. Nall

**59-39** Studies of Pilot Control During Launching and Reentry of Space Vehicles Utilizing the Human Centrifuge—C. H. Woodling and C. C. Clark

**59-40** Systems Using Solar Energy for Auxiliary Space Vehicle Power—A. E. von Doenhoff and J. M. Hallissy, Jr.

**59-41** The Problem of Escape from Satellite Vehicles—C. V. Carter and W. W. Huff, Jr.

**59-42** Application of Power Spectral Methods in Airplane and Missile Design—K. R. Thorson and O. R. Bohne

**59-43** A Study of the Effects of Wind Speed, Lapse Rate, and Altitude on the Spectrum of Atmospheric Turbulence at Low Altitude—R. M. Henry

**59-44** Analysis of Atmospheric Turbulence Spectra Obtained from Concurrent Airplane and Tower Measurements—U. O. Lappe, B. Davidson and C. B. Notess

**59-45** Cosmic Ray Detection by Visual Scintillations—H. Yagoda

**59-46** The Balloon-Borne Capsule as a Space Flight Trainer—E. E. Beson

**59-47** Infra-Red Spectroscopy from Balloons and the Possibility of Some Observations on the Biosphere—D. M. Gates

**59-48** The Strato-Laboratory as a Systems Testing Platform—James R. Smith

**59-49** Special Flight Testing for the Carrier Suitability of Naval Aircraft—R. M. Elder

**59-50** New Concept in USAF Flight Test—H. V. Leonhardt

**59-51** Man-Machine Integration in Space Vehicles—G. W. Hoover

**59-52** Implications of Space Radiations in Manned Space Flight—W. H. Langham

**59-53** Turbopumps for High-Energy Propellants—A. Ginsburg, W. L. Stewart and M. J. Hartmann

**59-54** A Look at Rocket Propulsion for the Next 25 Years—T. F. Dixon

**59-55** Thrust Control of Solid Propellant Rockets—H. W. Ritchey

**59-56** Large Deflections of Structures Subjected to Heating and External Loads—M. J. Turner, E. H. Dill, H. C. Martin and R. J. Melosh

**59-57** The Equation of Energy Balance for Fluttering Systems with Some Applications in the Supersonic Regime—J. D. C. Crisp

**59-58** Transonic and Supersonic Divergence Characteristics of Low-Aspect-Ratio Wings and Controls—D. J. Martin and C. E. Watkins

**59-59** Research Studies on a Ducted Fan Equipped with Turning Vanes—A. W. Gilmore and W. E. Grahame

**59-60** Convertible Turbojet Engines for VTOL Aircraft—M. A. Zipkin, R. J. Rossbach, and H. Brown

**59-61** The Space Age Effect on Management—E. Goetz, M. C. Demler, R. G. Folsom, i. N. Palley and E. Ledeen

**59-62** Viscous Aerodynamic Characteristics in Hypersonic Rarefied Gas Flow—R. F. Probstein and N. H. Kemp

**59-63** Viscous Hypersonic Similitude—W. D. Hayes and R. F. Probstein

**59-64** Propagation of Weak Disturbances in a Gas Subject to Relaxation Effects—F. K. Moore and W. E. Gibson

**59-65** Effectiveness of Radiation as a Structural Cooling Technique for Hypersonic Vehicles—R. A. Anderson and W. A. Brooks, Jr.

**59-66** Anisotropic Composite Thermal Structures for Hypersonic Flight—Luigi Broglio

**59-67** Thermo-Elastic Behavior of Simply-Supported Sandwich Panel Under High Temperature Gradient and Edge Compression—C. C. Chang and I. K. Ebcioglu

**59-68** Heat Conduction in a Melting Slab—S. J. Citron

**59-69** The Instrument Take-Off—G. D. Annin

**59-70** Integrating the Jet Aircraft into the ATC System—D. D. Thomas

**59-71** Operational Aspects of a Propjet Transport—W. H. Arata, Jr.

**59-72** The Manufacturer's Flight Test Philosophy—F. C. Rowley

**59-73** Requirements of High-Resolution Photography of the Planets—G. de Vaucouleurs

**59-74** An Aeronautical Engineering Educator's Viewpoint on the Challenge of Space Technology to Aeronautical Engineering Education—G. L. Von Eschen

**59-75** Electro-Gasdynamic Motion of a Charged Body in a Plasma—L. Kraus and H. Yoshihara

**59-76** Response, Accuracy and Display Requirements for Take-Off Monitors—R. P. Snodgrass

***Order by number from:*** **Special Publications Dept., IAS, 2 E. 64th St., New York 21, N.Y.**

# INTERNATIONAL AERONAUTICAL ABSTRACTS

## A Review of Worldwide Scientific and Technical Literature

Selected and prepared by the IAS Staff from currently released material received in the IAS Library. This research was supported in whole or in part by the Air Force Office of Scientific Research, Air Research and Development Command, United States Air Force.

The literature abstracted in this section is available through the lending or photocopying services of the IAS Library, New York.

PUBLISHED MONTHLY BY AERO/SPACE ENGINEERING

Official Publication of the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Volume 4, Number 2 February, 1959


### ACOUSTICS, SOUND, NOISE

THEORETICAL INVESTIGATIONS OF SONIC BOOM PHENOMENA. R. A. Struble, C. E. Stewart, E. A. Brown, and A. Ritter. USAF WADC TN 57-412 [AD 130883], Oct., 1958. 231 pp. 36 refs. Theoretical investigation to determine the pressure and shock wave characteristics due to a body in arbitrary motion. The propagation of these shocks through the atmosphere is studied, and the effects of parameters such as Mach Number, acceleration, altitude, and slenderness ratio are determined. The first part of the study presents the linear and nonlinear theory applicable to sonic boom. The second considers quantitative studies of sonic boom variables and contains an explicit and detailed evaluation of the physical characteristics of sonic boom. Curves depicting the effects of the significant physical variables and parameters are presented.

### AERODYNAMICS, FLUID MECHANICS

#### Aerothermodynamics

MOLECULAR AND COMPRESSIBILITY EFFECTS ON FORCED CONVECTION OF HEAT FROM CYLINDERS. D. C. Collis and M. J. Williams. Australia, ARL Rep. A, 110, July, 1958. 50 pp. 26 refs. Review of experimental and theoretical investigations on forced convection from cylinders in gas flows ranging from continuum, through slip, to free molecular flow. Restriction is made to Reynolds Numbers of less than 1,000. It is shown that in slip flow the reciprocal of the heat transfer parameter can be subdivided into contributions from continuum incompressible flow, molecular effects, and the effect of compressibility on the flow field. Topics discussed in some detail are Reynolds Number dependence, Mach Number effects, Knudsen Number correlations, and the nonlinear effect of temperature loading.

HEAT TRANSFER IN THE TURBULENT INCOMPRESSIBLE BOUNDARY LAYER. I - CONSTANT WALL TEMPERATURE. II - STEP WALL-TEMPERATURE DISTRIBUTION. III - ARBITRARY WALL TEMPERATURE AND HEAT FLUX. IV - EFFECT OF LOCATION OF TRANSITION AND PREDICTION OF HEAT TRANSFER IN A KNOWN TRANSITION REGION. W. C. Reynolds, W. M. Kays, and S. J. Kline. US, NASA Memo. 12-1-58W; Memo. 12-2-58W; Memo. 12-3-58W; Memo. 12-4-58W, Dec., 1958. 36; 38; 52; 28 pp. 55 refs. Experimental and theoretical investigation reporting the heat-transfer rates, velocity profiles, and temperature profiles for flow with a constant surface temperature and with a step-wall temperature. The results agree with theoretical results in the constant-temperature case, but differs in that of step-wall temperature, indicating in the latter the need for a better analysis. An integral analysis is made that agrees well with the data and allows a simple correction for the unheated starting length. A step-function analysis is used to predict heat-transfer rates for the case of variable wall temperature. Finally, an analysis of transition effects is made, which indicates that higher heat-transfer rates may occur for some distance downstream if the transition is very late.

COMPRESSIBLE TURBULENT BOUNDARY LAYERS WITH HEAT TRANSFER AND PRESSURE GRADIENT IN FLOW DIRECTION. Alfred Walz. US, NBS Rep. 6223 (AFOSR TN 58-635) [AD 162166], Dec. 1, 1958. 34 pp. 27 refs. Formulation of the empirical laws for dissipation and turbulent wall friction on the basis of available measurements for incompressible flow. A generalization to the compressible flow with heat transfer is made from physical considerations. Calculated results agree satisfactorily with available experimental data. Examples illustrating the application of the new method are given.

HEAT TRANSFER TO BOUNDARY LAYERS WITH PRESSURE GRADIENTS. R. A. Seban and H. W. Chan. USAF WADC TR 57-111 [AD 118075], May, 1958. 88 pp. 39 refs. Presentation of methods for predicting heat transfer to both lami-

nar and turbulent boundary layers. Variable free stream velocity and variable wall temperature are considered with the aim of specifying optimum calculation methods. For laminar boundary layers with almost constant properties, it appears that Lighthill's method, properly modified, has a general application, although in certain instances the error in the predicted heat transfer may attain 20%. When laminar flow has variable properties, the prediction methods become more complicated and a specific comparison with experiment is not possible. For turbulent flow there appears to be no preferred calculation method.

INFLUENZA DEL TRASPORTO DI MASSA SUL COEFFICIENTE DI CONVEZIONE. Giuseppe Trapanese. L'Aerotecnica, Aug., 1958, pp. 234-240. In Italian. Study of the suction-controlled thermal laminar boundary layer for Prandtl Numbers $\geq 1$. The thermal convection in the presence of condensation for an air flow parallel to a semi-infinite flat plate is analyzed, and the influence of this condensation is investigated.

O NAGREVANII I PLAVLENII TVERDOGO TELA OT TRENIIA. S. S. Grigorian. Prikl. Mat. i Mekh., Sept.-Oct., 1958, pp. 577-585. In Russian. Presentation and solution of problems covering the heating and melting of solid bodies due to friction. The two cases studied are: (a) friction between two solid bodies and (b) flow of viscous incompressible liquid around a solid body. The solution for the nonstationary heat-transfer problem in the case of known initial and boundary conditions is derived, the heat-transfer and the Navier-Stokes equations are introduced for the calculation of the liquid phase, the importance of the front between the liquid and the solid phase is stressed, and the simplified process used in the boundary-layer theory is indicated.

ÜBER ERWÄRMUNG VON IN DIE ATMOSPHÄRE EINTAUCHENDEN RAKETENKÖRPERN. W. Strubell. Astronautica Acta, Fasc. 3, 1958, pp. 182-187. 13 refs. In German. Analysis of the heating of rocket vehicles entering into the earth's atmosphere. Using results of meteor astronomy, an attempt is made to determine the causes leading to the evaporation of the rocket entering into the earth's atmosphere from space and the cases where it does not evaporate. The evaporation process is described. Assuming that its mass is constant, the loss in velocity of the immersing body is determined through the resistance law, the accuracy of the formula depending on the initial velocity of the entering body. The case of mass reduction is considered. Hope's theory on the motion of satellites through the atmosphere is presented. The critical velocity where vaporization stops is explained and determined mathematically.

## Boundary Layer

THE BOUNDARY LAYER EQUATIONS OF COMPRESSIBLE FLOW; SEPARATION. D. Meksyn. ZAMM, Sept.-Oct., 1958, pp. 372-379. 10 refs. Reduction of the equations of motion, continuity, and energy to two simultaneous equations. The result is applied to the problem of flow past a semi-infinite plane with separation induced by a shock wave.

MEASUREMENTS OF SKIN FRICTION IN A PLANE TURBULENT WALL JET. A. Sigalla. RAeS J., Dec., 1958, pp. 873-877. Test results showing that it is possible to describe the variation of skin friction coefficient by a formula similar to the Blasius one, which is based on experimental results of turbulent pipe flow. This is achieved by considering the inner layer of fluid between the wall and the position where the velocity is a maximum as a boundary layer with an outer uniform free stream of velocity equal to the local maximum velocity. Other measurements of velocity distribution indicate that, within the experimental range and accuracy, the velocity profiles in the jet are similar and that the rate of change of velocity and width of the jet can be expressed by simple power laws.

CALCULATION OF THE CROSS-STREAM WAVE LENGTH OF THE THREE-DIMENSIONAL TRANSITION PATTERN IN THE BOUNDARY LAYER ALONG A FLAT PLATE. J. R. Weske. U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-150 (AFOSR TN 58-864) [AD 203671], Nov., 1958. 25 pp. 10 refs. Analysis of three-dimensional transition motions in the boundary layer which show a pronounced pattern recurring periodically across the stream. It is assumed that secondary vorticity is a controlling factor and that viscous effects are of minor consequence. An optimum cross-stream wave length is computed which is numerically in agreement with experimental observations. The results of the computation point to the emergence of composite periodic vortex configurations.

HEAT TRANSFER AND BOUNDARY LAYER MEASUREMENTS IN A REGION OF SUPERSONIC FLOW SEPARATION AND REATTACHMENT. A. Naysmith. Gt. Brit., RAE TN Aero. 2558, May, 1958. 36 pp. Investigation at Mach Number 4 of local heat transfer rates downstream of a 15° wedge terminating in a step. In addition, pitot traverses were made on the wedge and downstream of reattachment. The results indicate that there is a local peak in the value of the heat transfer coefficient in the region where the flow reattaches, but it was not possible to measure the size or extent of this peak. Downstream of reattachment the heat transfer coefficient had about half of its value before separation; whereas inside the separated bubble behind the step, the heat transfer coefficient was about 15% of its value before separation.

UNSTEADY LAMINAR BOUNDARY LAYERS IN AN INCOMPRESSIBLE STAGNATION FLOW. Kwang-Tzu Yang. (ASME Annual Meeting, New York, Nov. 30-Dec. 5, 1958, Paper 58 - A-3.) J. Appl. Mech., Dec., 1958, pp. 421-427. Presentation of an exact solution for the special case of a flow velocity varying inversely with a linear function of time, together with calculated boundary-layer characteristics for different values of a flow parameter. Based

on the results of this exact solution, an approximate method of solution is proposed for a more general problem where the flow velocity changes arbitrarily with time. The results of five examples are shown and discussed in the light of other available solutions. Finally, the limitations of this approximate solution are pointed out and a possible remedy indicated.

## Control Surfaces

SIMPLIFIED LOADING FORMULAE FOR PULL-OUT MANOEUVRES OF TAILED AEROPLANES. Appendix I - DETAILS OF CALCULATING PEAKS OF NORMAL ACCELERATION AT C.G., RESULTING FROM TRAPEZOIDAL ELEVATOR INPUT. Appendix II - DETAILS OF CALCULATING PEAKS OF INCREMENTAL INCIDENCE OF THE TAIL, RESULTING FROM STEP ELEVATOR INPUT. Appendix III - DETAILS OF CALCULATING PEAKS OF INCREMENTAL INCIDENCE OF THE TAIL, RESULTING FROM TRAPEZOIDAL ELEVATOR INPUT. Appendix IV - DETAILS OF DERIVING APPROXIMATE FORMULAE FOR MAXIMUM DOWNLOAD ON THE TAIL (AS WORKED OUT BY D. N. FOSTER.) Appendix V - DETAILS OF CALCULATING NORMAL ACCELERATION AT TAIL, ESPECIALLY ITS PEAKS, RESULTING FROM STEP OR TRAPEZOIDAL ELEVATOR INPUT. Appendix VI - EFFECTS OF VARYING FORWARD SPEED ON TAIL LOAD. S. Neumark. Gt. Brit., RAE Rep. Aero. 2608, June, 1958. 75 pp. 15 refs. Presentation of a method for calculating the response quantities in pull-out maneuvers, based on trapezoidal elevator input. The method is applicable to all tailed elevator-controlled aircraft of arbitrary design and in arbitrary flight conditions including the full range of speeds well up into supersonic. Manual control operation and at least the basic case of power operation are both covered.

## Flow of Fluids

A MODIFIED TANGENT-GAS APPROXIMATION FOR TWO-DIMENSIONAL STEADY FLOW. G. Power and P. Smith. J. Fluid Mech., Nov., 1958, pp. 600-606. Analysis, using hodograph methods, of two-dimensional subsonic flows past certain cylinders in which the true pressure-volume relationship is replaced by various straight-line approximations. It is found that the approximation obtained by a least-squares method gives the best results. Comparison is made with values obtained by using the von Kármán-Tsien approximation and also with results obtained by the variational approach of Lush and Cherry.

SKIN FRICTION OF A FLAT PLATE IN THE MOLECULAR FLOW OF NON-MAXWELLIAN GAS. A. Takano. Japan Soc. Aero. Eng. Trans., No. 1, 1958, pp. 9-18. 14 refs. Presentation of the general kinetic theory for the free molecular flow of a non-Maxwellian gas. The distribution of the molecular velocities is supposed to follow the Maxwellian law with the addition of certain terms, in which the stress tensors and the thermal flows are involved. These quantities are expressed in terms of the space gradient of the mass flow velocities and the temperature, and determined from the slip flow theory based on the boundary layer approximation. The stress tensors are determined and the skin friction of the flat plate obtained from the kinetic theory. The result is shown to be in good agreement with that obtained from the kinetic theory of a Maxwellian gas in the limiting case of the infinite value of the Knudsen Number; however, the expression obtained underestimates the local skin friction coefficient in the slip flow region.

A NEW APPROACH TO THE THEORY OF SLENDER BODY IN COMPRESSIBLE FLOW. Haruo Moriguchi. Phys. Soc. Japan J., Nov., 1958, pp. 1, 384-1, 390. Establishment of a simple representation of the perturbations for a flow of compressible fluid and, for the case of a slender body, of approximate solutions which satisfy the exact boundary conditions. Higher order approximations for the equation may be found by the usual method of iteration.

ON TRANSONIC FLOW ABOUT SLENDER THREE-DIMENSIONAL BODIES. H. U. Thommen. Brown U., Div. Eng. (AFOSR TN 58-714) [AD 162 249], Sept., 1958. 135 pp. 14 refs. Theoretical and experimental investigation to obtain a suitable solution for flow around a not-so-slender body. The nonlinear differential equation for the perturbation potential of transonic flow about slender bodies is transformed into a nonlinear integral equation by means of multiple Fourier transforms. An attempt is made to linearize this equation by a suitable choice of the parameters, but owing to mathematical difficulties no rigorous treatment is possible. Comparison with experimental results reveals some very severe shortcomings which render the approximation inapplicable in its present form to flows with slightly subsonic but supercritical free stream. For slightly supersonic free stream the approximation seems fair, but, in this case, the experimentally obtained results are rather questionable.

PRESSURE DISTRIBUTIONS ON A TWO-DIMENSIONAL BLUNT-NOSED BODY AT VARIOUS ANGLES OF ATTACK. Victor Zakkay and A. K. Fields. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 461 (AFOSR TN 58-1016) [AD 162281], Oct., 1958. 22 pp. Experimental determination of pressure distributions at a Mach Number of 6, and comparison of these measurements and the velocity gradient with theoretical predictions. It is shown that Newtonian theory does not apply for bodies where the sonic point does not fall on the same radius of curvature as the stagnation point. A large reduction in stagnation point heat transfer is obtained as a result of increasing the radius of curvature of the body at the sonic point over that which exists at the stagnation point of constant radius of curvature models.

ON A POWER SERIES METHOD OF SOLUTION OF A BODY OF REVOLUTION AT AN ANGLE OF ATTACK IN HYPERSONIC INVISCID FLOW. T. Y. Li. Rensselaer Polytech. Inst. Res. Div. TR AE 5812 (AFOSR TN 58-956) [AD 205349], Aug.,

1958. 36 pp. Study of the equations of motion and the boundary conditions on the body surface and at the shock wave. For a small angle of attack, $\epsilon$, it is shown that the solution can be expressed as an ascending power series of $\epsilon$. Consequently, a sequence of differential equations with appropriate boundary conditions corresponding to various degrees of approximation is obtained. The zeroth-order approximation corresponds to the case of the axisymmetric flow past the body of revolution. The method provides a means for accurately determining the rate of change of lift coefficient with angle of attack and the rate of change of moment coefficient with angle of attack.

THE CONE-SPHERE IN HYPERSONIC HELIUM ABOVE MACH 20. R. H. Johnson. (IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-2.) Aero/Space Engrg., Feb., 1959, pp. 30-34, 53. 10 refs. Experimental investigation on cone-sphere bodies in hypersonic helium flows at Mach Numbers of 22 and 25 and test section pressures of the order of 2 mm. Hg. The relations between the shock wave and the body are obtained for a series of cone-sphere models with bluntness varying from a flat-ended circular cylinder to a hemisphere-cylinder. Shock-wave geometry measurements are made from schlieren photographs. Experiments indicate that the flow field may be approximated by either the simple sphere flow or the flat circular disc flow within determined ranges of the cone-sphere bluntness.

AERODYNAMIC FORCES ON A CYLINDRICAL SHELL IN PANEL FLUTTER. Maurice Holt. Brown U., Div. Appl. Math. Rep. (AFOSR TN 58-974) [AD 205598], Dec., 1958. 12 pp. Calculation of the aerodynamic forces resulting from the unsteady distortion of a circular cylinder of finite length in a uniform supersonic stream. The problem is very similar to that of finding the steady flow past a quasi-cylindrical duct. This has been recently solved by Randall in terms of modified Bessel functions of the second kind. The forces on the finite cylinder are compared with corresponding forces on an infinite cylinder. In the infinite case circumferential distortion introduces a constant factor into the expression for the surface pressure. On the other hand, on a cylinder of finite length, circumferential distortion causes the surface pressure to be damped in the axial direction. The effect of finite length of cylinder should, therefore, improve panel flutter characteristics.

PHENOMENOLOGICAL FREE STREAMLINE THEORY. I - FLOW PAST A NORMAL PLATE. Yōichi Mimura. Phys. Soc. Japan J., Nov., 1958, pp. 1, 361-1, 374. Study of the pressure distribution on a normal plate by determining the pressure distribution on a free streamline as a function of the distance from separation point. In the case when this distance is obtained only in the "free streamline range" (the range from the separation point to a distance equal to about one and a half of the breadth of the plate), the pressure distribution and other quantities on the normal plate are estimated with their probable deviations. The shape of the free streamline is also examined.

INTERACTION BETWEEN A SUPERSONIC STREAM AND A RECTANGULAR DEPRESSION ON A FLAT PLATE. M. G. Morozov. Sov. Phys. - Tech. Phys., Jan., 1958, pp. 144-149. Translation. Presentation of experimental results on the distribution of the static pressure and of the coefficients of recovery and heat transfer over the bottom of a transverse rectangular depression of variable length, cut in a plate located in a supersonic air stream. Experimental models and techniques are described. The substantial differences between the two arising flows are shown. The combined schlieren photographs, streamline patterns, and the corresponding curves for the two most characteristic depression dimensions are given.

SUPERFICI DI DISCONTINUITA IN MAGNETOFLUIDODINAMICA. L. G. Napolitano. L'Aerotecnica, Aug., 1958, pp. 210-220. In Italian. Derivation of the basic equations for discontinuities in magnetofluiddynamics, and discussion of their solutions in relation to contact and vortical discontinuities. The electric conductivity is considered to be infinite, constant, and variable with the absolute temperature. It is found that contact discontinuities are always possible in the first two cases, whereas vortical discontinuity surfaces are possible only when the magnetic field has no component normal to the surface itself ($H_n = 0$). For $\sigma = \sigma(T)$ vortical discontinuity surfaces are always possible, and their characteristics, when $H_n \neq 0$, depend upon the surface geometry and the tangential component of the electric field. The existence of contact surfaces implies the existence of discontinuities in the magnetic field unless the tangential component of the electric field vanishes.

THE EFFECTS OF COMBINED ELECTRIC AND MAGNETIC FIELDS ON HYPERSONIC COUETTE FLOW. Appendix A - NUMERICAL PROCEDURE FOR SOLVING EQUATIONS. Appendix B - EXACT EQUATIONS FOR PURE JOULE HEATING ($N_H = 0$, $N_E \neq 0$). Appendix C - CONSTANT PROPERTIES SOLUTION FOR SEVERAL SPECIAL CASES ($\bar{T}_w = 1$). Z. O. Bleviss. Douglas Rep. SM-23314, Oct., 1958. 47 pp. Extension of the Couette flow problem considered previously to include both radial magnetic fields and circumferential electric fields. Couette flow is regarded as an approximation to the fluid motion produced in the annulus between two coaxial circular cylinders of infinite length when the cylinders move axially relative to each other and the annular thickness is small compared with the cylinder radii. The effects of the electric and magnetic fields upon the velocity, temperature, electric current density, induced magnetic field distributions, skin friction, heat transfer, total drag, total current, and ratio of total drag to heat transfer are shown. Some general conclusions are made concerning the effects and possible usefulness of the presently considered configurations of electro-magnetic fields applied to the boundary layer of a body of revolution that is flying at hypersonic speeds and is slender enough so that its drag is primarily due to skin friction.

THE DISSOCIATION OF A PURE DIATOMIC GAS IN A LAMINAR BOUNDARY LAYER ON AN ADIABATIC FLAT PLATE. Gianni Jarre. Torino Polytech. Inst. Appl. Mech. Lab. TN 10 (AFOSR TN 58-944) [AD 205082], Sept., 1958. 18 pp. Analysis of the dissociation problem at hypersonic Mach Numbers. The boundary layer equations are applied and simplifying assumptions made. The thermo-chemical properties of the mixture of reacting molecules and atoms are specified. Two simplified methods, the integral and the stagnant film method, are applied and give very similar numerical laws describing the temperature-decay at the wall at the approach of the chemical equilibrium state. Two numerical examples show that the process of dissociation for the case considered is very slow.

LES ECOULEMENTS PERMANENTS DE REVOLUTION; METHODES DE CALCUL ET APPLICATIONS. M. Faury. Docaéro, Nov., 1958, pp. 31-44. In French. Derivation of the simple relationship existing between the mechanical and thermodynamic characteristics of an ideal fluid flow and the intrinsic path elements, in particular, the curvature. The application of these relationships leads to the determination of geometric paths of a flow whose behavior is assumed to be arbitrarily thermodynamic. Includes development of a method of calculation which can be used to determine the shape of a nozzle necessary to produce the desired velocity distribution along the axis. It can also be used to determine the exact structure of the flow, as well as the sonic line in the case of a convergent-divergent nozzle. Its usefulness in the design of centrifugal compressors is emphasized.

A NOTE ON THE COMPRESSION OF AIR THROUGH REPEATED SHOCK WAVES. J. L. Stollery and D. J. Maull. J. Fluid Mech., Nov., 1958, pp. 650-654. Comparison of calculations of the compression of air by repeated shock waves with the perfect-gas values given by Evans and Evans. Emphasis is placed on the increasing divergence of real gas from perfect-gas results as shock strengths are raised. The equations relating conditions across a shock wave are obtained in a convenient form for solution using a Mollier diagram.

O NELINEINOM OTRAZHENII SLABYKH UDARNYKH VOLN. O. S. Ryzhov and S. A. Khristianovich. Prikl. Mat. i Mekh., Sept.-Oct., 1958, pp. 586-599. In Russian. Investigation of the nonlinear reflection of weak shock waves. Includes a study of the physical conditions used to simplify the equations of gas dynamics describing nonstationary flows with small, but sharp, parametric changes in the medium. The exact (partial) solutions for the derived nonlinear differential equations are used to solve approximately the problem of nonlinear diffraction in the case of a rigid wall and angles of incidence near the critical.

A LINEARIZED ANALYSIS OF THE FORCES EXERTED ON A RIGID WING BY A SHOCK WAVE. F. E. Ehlers and E. M. Shoemaker. J. Aero/Space Sci., Feb., 1959, pp. 75-80, 107. Derivation of formulas for the pressure exerted on a half plane by an incident weak plane shock. The shock front was considered to be parallel to the edge of the half plane, but the angle of incidence was arbitrary. Three cases were considered: the half plane traveling (a) subsonically into the shock, (b) subsonically away from the shock, and (3) supersonically into the shock. A closed-form solution is also obtained for a rigid wedge which is motionless with respect to the acoustic medium. The analysis is carried out by transforming the wave equation to Laplace's equation by the Busemann conical transformation and then applying conformal mapping.

INVESTIGATION OF THE TRANSMISSION OF A SHOCK WAVE THROUGH AN ORIFICE. L. L. Monroe. GALCIT Memo. 46, Sept. 25, 1958. 54 pp. Investigation considering a shock wave propagating in air within a shock tube and reflected from an orifice plate. The strength or Mach Number of the transmitted wave is measured for a range of incident shock Mach Numbers from 3 to 9 for several types of orifices. The measured volumes of transmitted shock strength are compared with predicted values based on a theoretical one-dimensional flow model for both ideal and real gases. The one-dimensional flow model discussed yields a satisfactory prediction of the speed of the shock transmitted through the orifice. Depending on whether the flow losses through the starting shock wave configuration are greater than or less than those postulated in the plane wave of the one-dimensional model, the measured values of the transmitted wave Mach Number will correspondingly be lower or higher.

DYNAMICS OF RAREFIED GASES. I - FUNDAMENTAL EQUATIONS. Kichiro Takao. Japan Soc. Aero. Eng. Trans., No. 1, 1958, pp. 2-8. Presentation of a method, based on the Maxwell-Boltzmann equation, for treating the problem of dynamics of rarefied gases near a wall. The case where the Knudsen Number is arbitrary and the state of the gas slightly nonuniform is considered. The distribution of molecules impinging upon a wall is presented by a function different from that of molecules reflecting from the wall. The entire distribution is given by the sum of these two functions. As a result of splitting the distribution function in two parts, the boundary condition can be completely satisfied. Assuming that the gas is incompressible, a system of fundamental equations near a flat wall is derived.

THEORETICAL STUDIES OF UNSTEADY TRANSONIC FLOW. I - LINEARIZATION OF THE EQUATIONS OF MOTION. M. T. Landahl. Sweden, Flygtekniska Försöksanstalten, FFA Medd. 77, 1958. 18 pp. 25 refs. Derivation of the equations of motion for small perturbation unsteady nonviscous transonic flow; the requirements for their linearization are considered on a physical basis. The requirement for the transonic equation to be valid may be written $k >> |1 - M_L|$, where k is reduced frequency and $|1 - M_L|$ is the largest

departure of the local Mach Number from unity in the flow. This requirement, which is in essential agreement with earlier results, ensures that the slow-moving waves (receding waves) will have a wavelength that is small in comparison with the reference length of the body. Some properties of the nonlinear transonic solution are discussed, and the linearized transonic solution is shown to exhibit these properties correctly as the receding wavelength tends toward zero.

GIPOTEZA LOKAL'NOSTI V TURBULENTNOM DVIZHENII ZHIDKOSTI PRI NALICHII VIAZKOSTI. L. G. Loitsianskii. Prikl. Mat. i Mekh., Sep.-Oct., 1958, pp. 600-611. In Russian. Presentation of a hypothesis on the locality of turbulent motion in a viscous liquid. Results of experiments for determining the mean velocities near the body surface are presented, and the presence of a transition from the linear velocity profile (in the immediate vicinity of the surface) to the logarithmic profile (away from it) is shown. Extension of the hypothesis on the locality of the turbulent mixing mechanism and the Reynolds analogy between the transfer of the quantity of motion and heat content to the entire region of turbulent motion, where the interaction of molecular and molar processes occurs, permits a single approach to all existing semiempirical theories and the derivation of new friction and heat-transfer formulas for the turbulent motion. These formulas lead to continuous analytical expressions, or expressions having continuous first derivatives, covering velocity and excess-temperature profiles for the entire flow cross section, perpendicular to the direction of the motion, including the laminar, transition, and purely turbulent regions.

ON THE ORIGIN AND MECHANISM OF VORTEX MOTION AT THE INLET OF INTAKES PLACED NEAR A FLAT SURFACE. J. R. Weske. U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-152 (AFOSR TN 58-152) [AD 203672], Nov., 1958. 24 pp. 17 refs. Theoretical and experimental investigation to explain the mechanism by which a vortex is formed in the field of a sink which is located close to a solid surface, and to show that the various forms which it assumes may be related to the same pattern. The nature of the flow instability that initiates the circulatory motion is considered, as is the origin of the vorticity that is removed by the flux into the sink. The occurrence of vortex motion is traced to the effect of free flow along the flat plate and to the generation of secondary vorticity.

NONLINEAR PROBLEMS OF ONE-DIMENSIONAL WAVE PROPAGATION IN GASES (TREATED BY THE RITZ METHOD). I. M. Fyfe and K. Klotter. USAF WADC TR 58-293 [AD 155880], Aug., 1958. 66 pp. 14 refs. Investigation on the feasibility of applying the Ritz method to wave propagation problems involving one space coordinate in addition to the time. To apply the Ritz method it is necessary to obtain a functional in an integral which fully describes the problem and, if possible, contains only one dependent variable. The problems of obtaining that function and of selecting the appropriate assumed form of the solution are treated. The cases of a plane wave propagating in a tube and of spherical symmetrical waves are considered as examples. A comparison of results with experimental evidence is made.

## Internal Flow

A SIMPLE APPROACH TO AN APPROXIMATE TWO-DIMENSIONAL CASCADE THEORY. M. J. Schilhansl. (ASME Annual Meeting, New York, Nov. 30-Dec. 5, 1958, Paper 58 - A-23.) J. Appl. Mech., Dec., 1958, pp. 607-612. Analysis based on a singularity method in which the blade sections are replaced by sheets of vortices, sources, and sinks, and the flow induced by these singularities is calculated. The condition that the flow must be tangential to the blade surface leads to a relation between the geometrical shape of the blade sections (camber and thickness), the cascade parameters (solidity and stagger angle), and the singularity distributions along the mean camber lines. When these distributions are known, the pressure distribution and lift may be determined. A short, simple method is shown for calculating the velocities induced by the singularities.

TRANSONIC FLOWS THROUGH A STRAIGHT CASCADE OF SLENDER AIRFOILS. A. D. Wood. Brown U., Div. Eng. (AFOSR TN 58-732) [AD 162267], Aug., 1958. 163 pp. 23 refs. Investigation of the steady, transonic flow of an isentropic, isoenergetic fluid through an arbitrary two-dimensional cascade of airfoils. By application of a double exponential Fourier transform the nonlinear partial differential equation for the perturbation potential is transformed into a nonlinear integral equation which may be solved by an iterative procedure. Two methods are investigated with the object of finding a relatively simple first approximation to the solution in which the nonlinear effects are included. The general transonic result obtained contains the linear subsonic and supersonic solutions as special cases. Two parameters are chosen for the first method, and ways of selecting them are discussed. A general solution for an arbitrary lifting cascade is formulated, and a numerical example for the simpler nonlifting cascade of symmetric airfoils is presented. An additional method for the nonlifting cascade is investigated and found to yield good results. A comparison of theoretical solutions with experimental pressure distributions is made.

DIE STRÖMUNG DURCH EIN SCHWINGENDES UND ROTIERENDES RADIALES SCHAUFELGITTER. Wolfgang-Hermann Isay. (WGL Jahrestagung, Stuttgart, Oct. 11, 1958.) ZFW, Nov., 1958, pp. 319-328. 11 refs. In German. Study of flow through an oscillating and rotating radial cascade with sections designed on the basis of the method of singularities. The oscillations assumed are those for which all the blades of the cascade are subjected to the same conditions of flow simultaneously and, thus, to the same circulation. The assumption is introduced that the angular frequency of the blade oscillation is $N\omega$, where $\omega$ is the angular

velocity of the rotating blades and N the number of blades.

PERFORMANCE OF FLARED EXHAUST DUCTS SUITABLE FOR JET FLAP APPLICATIONS. R. C. Lopiccolo and R. Z. Nelsen, Jr. USAF WADC TR 57-592 [AD 151186], Apr., 1958. 40 pp. Test results for three flared ducts presented in the form of the velocity coefficient and flow coefficient versus pressure ratio. Also presented is the percent thrust loss relative to the cylindrical duct. Thrust losses as low as 2% are obtained for the best configuration tested and less than 10% for the worst. Flow distribution at the exit of the flared ducts was measured. This shows that maintaining uniform flow at the blowing slot for the two better ducts is not a problem, especially at the lower exit to inlet area ratios.

A TWO-DIMENSIONAL AIR INTAKE IN A SONIC STREAM. L. E. Fraenkel. J. Fluid Mech., Nov., 1958, pp. 629-649. 11 refs. Application of the transonic small-disturbance theory to a simplified model of the flow near the front of a ducted body. The body is assumed to consist simply of two parallel flat plates which extend from the inlet station to infinity downstream. The velocity far upstream is sonic, and the velocity far downstream in the duct, which is assumed to be known, is slightly subsonic. Air is therefore "spilled" around the intake edges. An analytic solution is found for the resulting flow field up to the limiting Mach wave, and asymptotic solutions are found for the supersonic flow and for the shock wave far from, and near, the intake edges. The pressure distribution along the outside walls is then known at both ends and its computation is completed by an empirical procedure.

CONFINED JETS AND RECIRCULATION PHENOMENA WITH COLD AIR. R. Curtet. Comb. & Flame, Dec., 1958, pp. 383-411. 16 refs. Development of an approximate theory of confined jets for two-dimensional and axisymmetric flow conditions, allowance being made for wall effect when studying the mixing of a jet with a surrounding stream enclosed in a duct. The experiments are described; they show that two distinct regimes can be identified, depending on the similitude parameter. The variation along the axis of a suitable shear stress parameter and its dependence upon the supply conditions to the nozzle are considered. The recirculation of an axisymmetric jet is examined, and the agreement between theory and practice is investigated.

ON THE BASE PRESSURE RESULTING FROM THE INTERACTION OF A SUPERSONIC EXTERNAL STREAM WITH A SONIC OR SUBSONIC JET. Wen-Lung Chow. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-4. 11 pp. 12 refs. Members, $0.50; nonmembers, $1.00. Investigation showing to what extent the base pressures for the present problem can be calculated by theoretical considerations. Previous investigations are discussed. The experimental apparatus is described, and a typical experimental result is evaluated to illustrate the appearance of three distinctly different regions. The jet interference effects are calculated by treating the flow components within the different flow models on a quantitative basis. The expansion at the base, the flow of the streams along the wake with mixing, the recompression at the end of the wake, and the conservation of mass in the wake are considered. Flow models for the various regions are represented graphically and a comparison of theoretical and experimental results is made.

EFFECTS OF COMPRESSIBILITY ON A LAMINAR WALL JET. N. Riley. J. Fluid Mech., Nov., 1958, pp. 615-628. Analysis of the effects of viscous dissipation, wall temperature conditions, and of the initial temperature of the fluid on the radial wall jet. On the assumption that the coefficient of viscosity is proportional to the temperature, it is shown that a similarity solution for the viscosity distribution exists, which is expressible directly in terms of the corresponding solution for an incompressible wall jet. For arbitrary Prandtl Number the energy equation is studied in detail and solutions are obtained for a variety of temperature conditions.

## Jet Flaps & Wings

LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH AN UNSWEPT, ASPECT-RATIO-10 WING, TWO PROPELLERS, AND BLOWING FLAPS. R. N. Griffin, Jr., C. A. Holzhauser, and J. A. Weiberg. US, NASA Memo. 12-3-58A, Dec., 1958. 47 pp. Investigation to determine the lifting effectiveness and flow requirements of blowing over the trailing-edge flaps and ailerons on a large-scale model of a twin-engine, high-aspect-ratio, thick, straight wing. With sufficient blowing jet momentum to prevent flow separation on the flap, the lift increment increased for flap deflections up to 80°. This lift increment also increased with increasing propeller thrust coefficient. The blowing jet momentum coefficient required for attached flow on the flaps was not significantly affected by thrust coefficient, angle of attack, or blowing nozzle height.

## Performance

LAGRANGE MULTIPLIERS AND QUASI-STEADY FLIGHT MECHANICS. Appendix - OPTIMUM AERODYNAMIC CONFIGURATIONS. Angelo Miele. Purdue U., Sch. Aero. Eng. Rep. A-58-4, May, 1958. 32 pp. 10 refs. Presentation of a general method for investigating optimum conditions for the quasi-steady mechanics of flight. For motion in a vertical plane the problem of extremizing an arbitrarily specified function of altitude, Mach Number, lift, path inclination, engine control parameter, and thrust inclination is considered for an aircraft which has to satisfy the equations of motion and three additional arbitrary constraints. A generalized solution is obtained in a determinantal form. The optimum ratio (R) of induced drag to zero-lift drag is evaluated for arbitrary relationships between zero-lift drag coefficient, induced drag coefficient, thrust, specific fuel con-

sumption, and Mach Number. Design problems are also investigated, such as those associated with the selection of the best wing surface or the best aspect ratio for a given performance to be optimized.

## Wings & Airfoils

A METHOD OF CALCULATING THE VELOCITY DISTRIBUTION ON ANNULAR AEROFOILS IN INCOMPRESSIBLE FLOW. Appendix I - THE VELOCITY FIELD OF A SOURCE DISTRIBUTION ON A CIRCULAR CYLINDER. Appendix II - THE AXIAL VELOCITY FIELD OF CERTAIN VORTEX DISTRIBUTIONS. J. A. Bagley, N. B. Kirby, and P. J. Marcer. Gt. Brit., RAE TN Aero. 2571, June, 1958. 32 pp. 11 refs. Development of a method for calculating the velocity distribution on annular airfoils of moderate thickness/chord ratio and camber, and reasonably large radius/chord ratio (the order of one or greater), based on the use of distributions of singularities on a cylinder whose velocity fields have been tabulated. The annular wing at zero incidence is treated first, followed by that at incidence.

## AEROELASTICITY

CALCULATED DERIVATIVES FOR RECTANGULAR WINGS OSCILLATING IN COMPRESSIBLE SUBSONIC FLOW. D. E. Lehrian. Gt. Brit., ARC R&M 3068, 1958. 15 pp. BIS, New York, $0.99. Application of the simple approximate equivalent wing theory with the vortex-lattice method of downwash calculation to obtain flutter and stability derivatives for rectangular wings describing plunging and pitching oscillations in subsonic flow. The derivatives for the wing of aspect ratio 4 at Mach Number of 0.866 are compared with values calculated by a method based on exact theory; at this Mach Number it is found that the present method is sufficiently accurate only for a limited range of the frequency parameter. At low values, the pitching-moment derivatives for this wing are in reasonable agreement with those calculated by the Multhopp-Garner method and with results from wind-tunnel tests at high subsonic Mach Number.

THE NATURAL FREQUENCIES OF VIBRATION OF TRIANGULAR CANTILEVER PLATES OF UNIFORM THICKNESS. P. W. Kleeman. Australia, ARL Rep. SM.262, June, 1958. 24 pp. Calculation of the natural frequency parameters for the vibration of triangular plates with tip angles of 30°, 60°, and 90° by an energy method using an inextensional theory for thin plates. The results provide an approximation to the large deflection problem of triangular cantilever plates. Data are given to enable the stress distribution in the plate to be calculated. The results are compared with experimental small deflection frequencies and are between 5% and 10% aboves these values.

AEROELASTIC PROBLEMS ASSOCIATED WITH HIGH SPEEDS AND HIGH TEMPERATURE. E. G. Broadbent. RAeS J., Dec., 1958, pp. 867-872. Analysis of two problems in which chordwise distorsions are important. The first relates to static distortion of a solid wing at high temperature, using nonlinear relations derived by Mansfield. It is shown that the chordwise distortion is stabilizing as regards divergence, but leads to considerable loss of lift. The second example deals with the effect of chordwise distortion on wing flutter and shows that, in this case, the flutter speed can be reduced.

AN EXPLORATORY INVESTIGATION OF SOME AERODYNAMIC HEATING EFFECTS ON FLUTTER. S. I. Gravitz. MIT ASRL TN 74-1 (AFOSR TN 58-972) [AD 205600], Sept., 1958. 83 pp. 34 refs. Theoretical and experimental investigation of the effects of rapid change in Mach Number on the flutter characteristics of supersonic wings, and study of the feasibility of utilizing a heated model in a low stagnation temperature wind tunnel to observe aerodynamic heating effects. Some existing theoretical techniques are briefly reviewed and applied to the case of a wing undergoing rapid deceleration from a high Mach Number to a lower one. Estimates of heat transfer coefficients and recovery factors are used to evolve approximate transient temperature and stress distributions which result in changes in the effective stiffness of the wing. A series of experiments show that for a model wing heated to a temperature of about 500°F. and then injected into the airstream, the flutter is appreciably different from that of an identical cold wing.

ON PANEL FLUTTER IN THE PRESENCE OF A BOUNDARY LAYER. J. W. Miles. (3rd Symposium High-Speed Aerodynamics & Struc., San Diego, Mar. 25-27, 1958.) J. Aero/Space Sci., Feb., 1959, pp. 81-93, 107. 11 refs. Analysis concluding that the pressure of a boundary layer has two distinct effects on the flutter of an infinite panel. First, the acoustic coupling between surface waves on the panel and sound waves in the outer flow is reduced. Second, energy can be transferred from the shear flow in the boundary layer to the panel if the surface wave speed is equal to the local speed in the shear profile at a point of strong profile curvature. The study indicates that the former effect should predominate in typical configurations and may reduce the degree of instability predicted in the absence of the boundary layer.

ESSAIS DE FLOTTEMENT SUR MAQUETTES AUTOPROPULSEES SOL-SOL, DANS LE DOMAINE TRANSSONIQUE; COMPARAISON DES RESULTATS OBTENUS EN AIR LIBRE ET DES RESULTATS CALCULES OU OBTENUS EN SOUFFLERIE. H. Loiseau. La Recherche Aéronautique, Sept.-Oct., 1958, pp. 43-51. In French. Description of flutter tests on self-propelled ground-to-ground models in the transonic region. Includes a description of model types and a comparison between wind-tunnel and free-flight measurements on dynamically similar wings, as well as between theoretical and experimental results.

EIN BEITRAG ZU DEN ERZWUNGENEN SCHWINGUNGEN EINER MEMBRAN. Max Hieke.

ZAMM, Sept.-Oct., 1958, pp. 356-368. In German. Derivation of a solution of the inhomogeneous differential equation for a vibrating circular membrane with fixed boundary when the force is a step function of axial symmetry. The Weber equation for the Bessel function of zero order is used, and the case of static as well as periodic force is studied by means of well-known integral theorems. By a superposition of forces used most cases of axial symmetry can be represented.

## AIRPLANES

### Control Systems, Automatic Pilots

FLIGHT CONTROL-AIRFRAME SYSTEM OPTIMIZATION. I. L. Ashkenas and D. T. McRuer. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-12. 35 pp. Members, $0.50; nonmembers, $1.00. USAF-supported development of an optimization system for control analysis considering both the airframe and flight controller to be alterable elements. Such a system involves the selection of desirable relative locations for the poles and zeros of the airframe and controller transfer functions. Analysis starts with the airframe equations of motion and reduces them to approximate factored transfer functions. These define servo terms and allow a ready synthesis of the complete system. A simplified example is then used to illustrate possible effects of airframe alteration upon the complete airframe-controller system.

## COMPUTERS

ENERGY VERSUS COMPATIBILITY ANALOG IN ELECTRICAL SIMULATORS OF STRUCTURES. F. L. Ryder. J. Aero/Space Sci., Feb., 1959, pp. 108-116. 11 refs. Comparison of two methods of simulation by using several illustrative cases in which the deformations and their compatibility are not considered explicitly, but instead the simulation of the energy in the structure is provided for by resistive power loss in the static case and by inductive and capacitive energy in the dynamic case. In most structures considered the energy type of approach leads to a drastically simpler theoretical treatment than the compatibility approach.

## CONTROL THEORY

THEORIE GENERALE; CONCEPTION ET CALCUL DES SERVO-MECANISMES. R. Moreau. France, ONERA Pub. 93, 1958. 94 pp. 25 refs. In French. Derivation of the general theory and analysis of the basic concepts of servomechanisms. The study covers linear or quasi-linear systems and is performed in order to provide a method directly applicable to practical cases. The Laplace transform is used, and certain specific aspects of electronic servomechanisms with thyratrons are also considered. Includes development of a semi-theoretical method of calculation for the optimum adaptation of servosystems, as well as survey of previously developed methods.

## FUELS & LUBRICANTS

DELAIS D'ALLUMAGE DU COMBURANT PERCHLOROSULFONITRIQUE ASSOCIE A DIVERS COMBUSTIBLES. Hélène Moutet. La Recherche Aéronautique, Sept.-Oct., 1958, pp. 23-33. In French. Description of a method for measuring the ignition delay of perchlorosulphonitric in combination with various fuels. Includes details of the laboratory test rig in which contact with fuel was detected electrically and the onset of combustion by means of a germanium photocell, sensitive to infrared; the preparation of the reagent; and tests on pure fuels (furfuryl alcohol, xylidine, aniline) and mixtures of these and acetone, carbon disulphide, and others.

## MATERIALS

### High Temperature

PROBLEMES METALLURGIQUES POSES PAR LES TURBOREACTEURS. R. Brunetaud. Tech. & Sci. Aéronautiques, Apr., 1958, pp. 71-84. In French. Survey of metallurgical problems arising in connection with turbojet power plants. The operation of various power plant types is described, including the effect of flight conditions; problems encountered in different parts of the system, such as the turbine, the combustion chamber, casings, and compressor blades, are discussed, as well as those pertaining to the choice of materials and their specific application. The performance achieved with currently used materials is evaluated as are the possibilities of cermets, classical, and new metals. The properties of nonmetallic materials are also evaluated in terms of their use as structural and coating materials.

### Metals & Alloys

LES MATERIAUX UTILISES EN AERONAUTIQUE. R. Lachenaud. Tech. & Sci. Aéronautiques, June, 1958, pp. 91-99. In French. Detailed survey of materials used in aeronautics including: (a) evaluation of the reasons for selecting currently used materials and analysis of some related problems; (b) determination of the trend in the development of new alloys; and (c) tentative definition of the requirements for future research on ballistic missiles. The study covers problems connected with the thermal barrier, as well as those of aircraft not subjected to kinetic heating, and is limited to materials used for aircraft structures alone, excluding the landing gear. Data are presented on the families of materials including light alloys, steel, and plastics; machining, forming, and welding processes; the distribution of various materials in aircraft and helicopter components; the form in which these materials are used; the size of various parts; and the properties of materials for temperatures below 200°C., as well as those which could be used in the range of 200°C. to 500°C.

FIZIKO-KHIMICHESKIE IAVLENIIA PRI DEFORMATSII METALLOV. V. I. Likhtman and E. D. Shchukin. Uspekhi Fiz. Nauk, Oct., 1958, pp. 213-245. 74 refs. In Russian. Survey and evalu-

ation of basic results of investigations on the occurrence of physicochemical phenomena in the deformation of metals. The theoretical interpretation of these results in terms of the dislocation theory is particularly emphasized. The phenomena studied cover (a) the mechanism and the laws governing the formation of solid bodies of given structure and mechanical properties; (b) the mechanism of deformation, processing, and rupture of solid bodies, taking into account the effect of such factors as composition, structure, temperature, and the surrounding medium. Test methods are also described and strength, plasticity, stresses, creep, and temperature effects are considered.

EFFECT OF REST PERIODS ON FATIGUE OF HIGH-PURITY ALUMINUM. J. W. Berry, J. Lemaitre, and S. R. Valluri. US, NASA Memo. 11-21-58W, Dec., 1958. 20 pp. Investigation indicating that resting at room temperature after stressing at elevated temperatures up to 450°F. has no effect on the fatigue life of high-purity aluminum. However, an increase in fatigue life may be obtained by resting at elevated temperatures after stressing at room temperature. It appears that the maximum benefit is obtained by having the rest period at a temperature below the recrystallization temperature.

## Nonmetallic Materials

COMPORTEMENT DES MATIERES PLASTIQUES TRANSPARENTES AU CHOC THERMIQUE. A. Kh. Iablokoff and M. Hédiard. La Recherche Aéronautique, Sept.-Oct., 1958, pp. 35-42. In French. Investigation of the thermal behavior of transparent plastic materials such as might be used in high-speed aircraft or missiles. Includes description of tests under conditions of both simple and thermal shock at temperatures ranging from -70°C. to 300°C. and back to -70°C. Materials tested include plasticized and nonplasticized plexiglas, diallyl phthalate, and glass. Bending, color, transparency, and crazing measurements were also made. Results indicate that these materials can withstand relatively high temperatures if the thermal shock is of short duration.

## MISSILES

TWO NON-LINEAR PROBLEMS IN THE FLIGHT DYNAMICS OF MODERN BALLISTIC MISSILES. J. D. Nicolaides. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-17. 27 pp. 54 refs. Members, $0.50; nonmembers, $1.00. Development of approximate models to analyze two types of nonlinear flight instability - Magnus instability and catastrophic yaw. Actual missile flight failures fall into two distinct groups, one characterized by missiles having a large rolling velocity and the other by having a small rolling velocity. These two groups are treated separately by approximate mathematical models. Both experimental and analytical applications of these models are made and discussed.

DETERMINING AIR REACTIONS ON MOVING VEHICLES. I - METHODS OF FREE BALLISTICS. M. Z. Krzywoblocki. USAF WADC TR 56-51, Pt. I [AD 161003], Nov., 1958. 132 pp. 628 refs. Description and review of the ballistic theories used to calculate the trajectory of a missile. The pertinent integration procedures are discussed. The various forms of air reactions used (primarily resistance or drag) are listed and their proper place in the overall scheme noted. General conclusions are drawn as to the extent to which the methods of free ballistics progressed toward the complete solution of the problem of determining air reactions on a moving vehicle.

GUIDANCE REQUIREMENTS OF BALLISTIC SATELLITES. M. J. Stateman. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-30. 10 pp. Members, $0.50; nonmembers, $1.00. Analysis of ballistic orbit parameters to estimate the accuracies of guidance systems used to launch the Soviet satellites. The errors in launch variables are obtained from the differences between the actual satellite orbit and the assumed desired orbit. These differences are related to guidance system accuracy. Applying the same accuracy capability to ICBM vehicles, the errors at impact are determined in order to show the meaning of these results in slightly different terms.

DYNAMIC LONGITUDINAL STABILITY EQUATIONS FOR THE RE-ENTRY BALLISTIC MISSILE. E. V. Laitone. J. Aero/Space Sci., Feb., 1959, pp. 94-98. Study of the range of validity of the usual linearized equations describing the dynamic longitudinal stability of a nonrolling ballistic missile attempting to follow a nearly zero angle of attack flight path while either accelerating or decelerating. In order to demonstrate that only the first-order terms can be rigorously justified, the ordinary second-order linear differential equation predicting the oscillations in angle of attack is derived by two entirely different approaches. The first method follows the usual procedure of small perturbations in the flight trajectory equations, while the second method utilizes Euler's dynamic equations, for axes that are rigidly fixed in the moving body. It is found that acceleration increases the damping while deceleration decreases the damping of any stable oscillation.

DURATA DI COMBUSTIONE OTTIMA NEI RAZZI D'ALTA QUOTA. Licio Giorgieri. L'Aerotecnica, Aug., 1958, pp. 195-209. In Italian. Presentation of a method to determine the optimum burning time for each stage of high-altitude rockets, in order to achieve the maximum all-burnt equivalent velocity for a given rocket-propelled payload by means of the minimum multistage launching vehicle. The method is developed in the absence of atmospheric drag, but in the presence of gravitational fields and structural stresses. Therefore it is not suitable for a single-stage rocket, but provides good results in the case of multi-stage rockets. Gravitational and payload efficiencies, together with a new kind of propulsive efficiency, are introduced for a systematic evaluation of the losses. Acceleration is evaluated for the case when dead weight plus propellant weight is a minimum. Sim-

plified equations are given and diagrams plotted for practical evaluation of all interested parameters in the case of single-, two-, and three-stage rockets.

## POWER PLANTS

### Jet & Turbine

LA PULVERISATION DES CARBURANTS LIQUIDES PAR INJECTION CENTRIFUGE. R. Kling. La Recherche Aéronautique, Sept.-Oct., 1958, pp. 13-21. In French. Description of a fuel injection system for turbojet combustion chambers consisting essentially of a wheel mounted on the turbine shaft and pierced with radial channels leading from the periphery to an axial supply duct. Under the action of centrifugal force the liquid fuel is accelerated through the channels and injected at high speed into the combustion chamber where it is then atomized. The structure of the liquid jets, as well as that of the final mist, is studied as function of the basic parameters: speed of rotation and rate of fuel supply. A description of the experimental model, test equipment, and measuring techniques is included and the results are evaluated in terms of high-altitude application.

NON-STALL NORMAL MODE FLUTTER IN ANNULAR CASCADE. I - THEORETICAL STUDY. II - EXPERIMENTAL STUDY. Jumpei Shioiri. Japan Soc. Aero. Eng. Trans., No. 1, 1958, pp. 26-45. 12 refs. Theoretical study of the nonstall flutter in axial flow machine blading. The flutter of the unshrouded annular cascade is treated from the standpoint of the vibration theory, the cascade being regarded as a many-degree-of-freedom system. The application of the theory for the bending mode is presented. The critical flutter is calculated by applying the thin airfoil method for cascading blades. Numerical results for some examples typical of compressor and turbine cascades indicate the possibility of the bending flutter in the current axial flow machine.

EXPERIMENTAL STUDY OF A REVERSED JET FLAMEHOLDER. G. A. Agoston, A. W. Noon, and T. D. Witherly. (Comb. Inst. West. States Sect. Winter Meeting, Pasadena, Jan. 20, 1958.) Comb. & Flame, Dec., 1958, pp. 333-347. 15 refs. USAF-supported experimental investigation of the physical structure of the jet and the flame, the phenomenon of unstable burning, and the mechanism of stable burning. The experimental apparatus and procedures are described. Observations of the flow field and flame behavior were made by means of time-exposure photographs, high-speed motion pictures, and spark shadowgraphs. Evidence indicating the occurrence of recirculation was obtained. The influence of nonuniform fuel concentration patterns in the main stream on flame stability limits is investigated. Results are discussed, and a mechanism plausible in the light of current observations is proposed.

### Rocket

DIGITAL COMPUTER ANALYSIS OF TRANSIENTS IN LIQUID ROCKET ENGINES. P. Kluger and E. C. Farrel. Jet Propulsion, Dec., 1958, pp. 804-809. Development of a digital computer program for engine transient study in order to obtain an evaluation of pressure surges in the propellant system during startup and shutdown. The mathematical model used for propellant line representation is based on the water-hammer theory as originally developed by Allievi. Line equations and component transfer functions have been programed in a general manner, allowing routine parameter changes to be executed without the need of major reprograming. The analysis determined the values of instantaneous propellant flow and transient pressures at points of interest in the system for successive time intervals.

## RESEARCH, RESEARCH FACILITIES

### Wind Tunnels

THE THEORETICAL PERFORMANCES OF SHOCK TUBES DESIGNED TO PRODUCE HIGH SHOCK SPEEDS. B. D. Henshall. Gt. Brit., ARC CP 407, 1958. 23 pp. Presentation of ideal-gas calculations on the performance of a double-diaphragm shock tube using hydrogen as the driver gas, argon in the intermediate section, and air as the final driven gas. It is shown that the shock tube can simulate the velocity and stagnation enthalpy appropriate to the re-entry of a satellite into the atmosphere. Comparison with a single-diaphragm tube having a combustion driver shows that the experimental difficulties concerning controlled and complete burning of combustible gas mixtures encountered with the combustion driver do not occur with the present system.

INFLUENCE OF DIAPHRAGM OPENING TIME ON SHOCK-TUBE FLOWS. D. R. White. J. Fluid Mech., Nov., 1958, pp. 585-599. 12 refs. USAF-supported analysis considering a problem in which the finite time required for removal of the diaphragm can result in an appreciable modification of the shock-tube flow for the case of the large diaphragm pressure ratios. For a monatomic driver/diatomic driven gas combination, this opening time can cause generation of a shock significantly stronger than predicted by the usual model. Expected shock-tube performance curves have been constructed using models of shock tube flow, which assume instantaneous diaphragm removal, and for a suggested model based on a finite rupture time for the diaphragm. Agreement between experiment and the latter model is, in general, good, and the differences are qualitatively accounted for by the pressure waves expected to result from mixing between driver and driven gases at the contact surface.

## ROTATING WING AIRCRAFT, HELICOPTERS

COMPARISON OF CURRENT OPERATIONAL ROTOR SYSTEMS AND A ROTOR HAVING FLOATING HUB AND OFFSET CONING HINGES. M. D. Marks. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-26. 15 pp. Members, $0.50; nonmembers, $1.00. Study of operational features of a rotor system considering stability, vibrations, performance, capability, fatigue, and maintenance. It is shown that the longitudinal stability character-

istics are improved by providing for stability with angle of attack and increased damping in pitch. Lateral dynamic stability and roll characteristics are improved through the sizable increase in roll damping. The response to gusts either in hovering or forward flight is reduced by the alleviation afforded by the pitch-cone coupling. The action of the floating hub during rapid pull-up greatly reduces the possibility of interference between rotor and fuselage. Ground resonance and associated concern for proper damper maintenance, oleo and tire inflation, as well as blade tracking is eliminated.

ANALYTICAL AND EXPERIMENTAL DETERMINATION OF THE COUPLED NATURAL FREQUENCIES AND MODE SHAPES OF A DYNAMIC MODEL OF A SINGLE-ROTOR HELICOPTER. M. A. Silveira and G. W. Brooks. US, NASA Memo. 11-5-58L, Dec., 1958. 42 pp. 11 refs. Calculation of the frequencies and mode shapes for helicopters and comparison with measured values. The results show good agreement and indicate that the frequencies and mode shapes can be adequately predicted if the structural properties of the helicopter are known.

## SPACE TRAVEL

THE DETERMINATION OF ROUND-TRIP PLANETARY RECONNAISSANCE TRAJECTORIES. R. H. Battin. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-31. 35 pp. Members, $0.50; nonmembers, $1.00. Analysis of purely geometrical problem of determining the various conic paths connecting two fixed points and having a focus which coincides with a fixed center of force. The conics studied include an ellipse, a hyperbola, and a parabola. An analytic functional relationship between the latus rectum and the major axis of the conic path is obtained. The time of flight for a conic trajectory is determined. The velocity requirements needed in order that a spaceship may attain a suitable interplanetary orbit are analyzed by using a simplified model of the solar system. The problem of non-stop round-trip interplanetary trajectories is considered, and a method of computation is presented. The various coordinate systems necessary for determining planetary reconnaissance trajectories in a true model of the solar system are presented.

NAVIGATIONAL REQUIREMENTS FOR THE RETURN TRIP FROM A SPACE VOYAGE. R. M. L. Baker, Jr. (Inst. Navigation 14th Annual Meeting, Santa Barbara, June 21, 1958.) Navigation, Autumn, 1958, pp. 175-181. Discussion covering such re-entry techniques as braking ellipses or skipping, as well as evaluation of special cooling devices and retro-rockets. The regime of flow encountered during high-speed re-entry is determined, and the altitude where aerodynamic heating exceeds radiative cooling is estimated. It is shown that high speed re-entry, during the braking ellipses, involves low-drag accelerations and occurs primarily in the transitional and slip-flow regimes. The adjustment of the trajectory for greatest deceleration and the case of low-thrust trajectories are considered. Re-entry from ballistic orbits is analyzed. A return trip from Venus is treated briefly as an example. The effects of elliptical braking, heat, and solar and lunar perturbations are evaluated.

OPTIMAL ESCAPE FROM A CIRCULAR ORBIT. D. F. Lawden. Astronautica Acta, Fasc. 3, 1958, pp. 218-233. Presentation of the general theory of optimal escape of a rocket from a circular orbit about a center of inverse square law attraction and application to the case of a rocket whose motor thrust causes an acceleration which is of constant magnitude and large by comparison with the gravitational acceleration in the circular orbit. The optimal thrust direction program is computed. The problem of optimal escape employing a small thrust is solved by a direct method and it is found that, over the major portion of the escape trajectory, the direction of thrust must bisect the angle between the direction of motion and the perpendicular to the line joining the rocket to the center of attraction. It is concluded that if escape is effected from a circular orbit by aligning the motor thrust with the direction of motion, the propellant expenditure will be very near minimal.

THREE-DIMENSIONAL ORBITS OF EARTH SATELLITES, INCLUDING EFFECTS OF EARTH OBLATENESS AND ATMOSPHERIC ROTATION. Appendix A - APPROXIMATE SOLUTION FOR TWO-DIMENSIONAL TRAJECTORIES NEAR CIRCULAR ORBITAL SPEED TOGETHER WITH NUMERICAL EXAMPLE. Appendix B - APPROXIMATE EXPRESSION FOR ECCENTRICITY FOR VALUE OF $V_\varphi$ SMALL COMPARED TO $V_c$. Appendix C - CHANGE IN PERIGEE ALTITUDE DUE TO OBLATENESS; GRAVITATIONAL FIELD FOR EQUATORIAL ORBITS. J. N. Nielsen, F. K. Goodwin, and W. A. Mersman. US, NASA Memo. 12-4-58A, Dec., 1958. 85 pp. 15 refs. Presentation of a set of equations which may be used for calculating complete trajectories of earth satellites from outer space to the ground under the influence of air drag and gravity, including oblateness effects. Equations of motion based on an "instantaneous ellipse" technique, with polar angle as an independent variable, were found suitable for automatic computation of orbits in which the trajectory consists of a number of revolutions. For the terminal phase, equations of motion using time as an independent variable were found more suitable. Several sample calculations were performed to study the effect of the earth's oblateness and the atmosphere's rotation on the motion and the point of impact.

RADIOASTRONOMICHESKIE ISSLEDOVANIIA S POMOSHCH'IU ISKUSSTVENNYKH SPUTNIKOV ZEMLI. G. G. Getmantsev, V. L. Ginzburg, and I. S. Shklovskii. Uspekhi Fiz. Nauk, Oct., 1958, pp. 157-161. 11 refs. In Russian. Discussion of the importance of satellite data in obtaining information on the electron component of cosmic rays, leading to the determination of the density of interplanetary gas. Such problems as the selection of apparatus, the type of antenna best suited for satellite installation, weight requirements, the effect

of satellite rotation on the orientation of antennas, and the effect of interference are analyzed. It is shown that the installation of two antennas would be advantageous for measuring polarization.

OBSERVATION OF A SATELLITE NEAR ITS CULMINATION. Alessandro Boni. (8th Internatl. Astron. Congr., Barcelona, Oct. 6-12, 1957.) Astronautica Acta, Fasc. 3, 1958, pp. 188-217. Presentation of equations describing the tracking process for a satellite near its point of culmination with respect to the observer. In such a point the altitude angle becomes stationary and the azimuth angular velocity remains almost constant during a short time interval.

## STRUCTURES

### Beams & Columns

ON THE USE OF LINEARIZED YIELD CONDITIONS FOR COMBINED STRESSES IN BEAMS. R. Sankaranarayanan and P. G. Hodge, Jr. J. Mech. & Phys. Solids, Nov., 1958, pp. 22-36. 15 refs. Derivation of yield criteria in terms of stress resultants for typical engineering structures using the first fundamental theorem of limit analysis. These yield criteria, which are often nonlinear, are then replaced by inscribed piecewise linear approximations. The complete solutions based on these approximate yield criteria provide lower bounds; the corresponding values for the upper bound can be obtained by multiplying the lower bound values by a suitable factor.

THE INFLUENCE OF MATERIAL DAMPING ON NON-CONSERVATIVE REACTIONS OF ELASTIC BEAMS DURING TORSIONAL AND LONGITUDINAL VIBRATIONS. Józef Więckowski. Arch. Mech. Stosowanej, No. 4, 1958, pp. 479-497. Investigation covering the case of torsional vibration of a circular beam and longitudinal vibration of beams and coil springs. The method for calculating material damping is presented, and the coefficients of material damping for various materials are determined. The influence of damping material on the reactions of infinite elastic beams undergoing torsional vibration is examined by appraising the damping correction. Two examples are given showing the existence of such a minimum value of the product $\varkappa_{min} = (\omega L)_{min}$ ($\omega$ - angular frequency of forced vibration, L - beam length), that for $\varkappa > \varkappa_{min}$ the beam reaction can be calculated as for an infinite beam without internal friction. An appraisal of $\varkappa_{min}$ is made, and an interesting dependency of the maximum stress wave length $\eta_{max}$ is indicated. The analogy between torsional and longitudinal vibration is used to describe the longitudinal vibration of beams and coil springs.

### Cylinders & Shells

FLEXURAL VIBRATIONS OF A THICK WALLED CIRCULAR CYLINDER ACCORDING TO THE EXACT THEORY OF ELASTICITY. J. E. Greenspon. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-14. 11 pp. Members, $0.50; nonmembers, $1.00. Presentation of curves for phase velocity and frequency as a function of wavelength and wall thickness ratios. Included are some comparisons between the exact theory, the Timoshenko beam theory, and the shell theory.

A STUDY OF CREEP COLLAPSE OF A LONG CIRCULAR CYLINDRICAL SHELL UNDER UNIFORM EXTERNAL PRESSURE. N. J. Hoff, W. E. Jahsman, and W. Nachbar. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-3. 14 pp. Members, $0.50; nonmembers, $1.00. Theoretical study of the creep problem. Equations are developed for the time behavior of the shape of the cross section under various conditions. Explicit solutions are obtained for the particular case of the cubic creep law. It is shown that the nondimensional amplitude of the cross-sectional mode shape becomes infinite in a finite time. Curves of shape factor versus time and of collapse time versus initial value of the shape factor are presented. An explicit expression for, and a curve of, the expected variation in collapse time owing to incontrollable deviations from a nominal initial value of the shape factor are given. The expected variation is shown to be small for a sufficiently large nominal initial shape factor value.

ON THE THEORY OF NEARLY SPHERICAL THIN SHELLS. Gunhard-Aestius Oravas. ZAMM, Sept.-Oct., 1958, pp. 379-386. Derivation of an approximate solution for the boundary disturbance of thin elastic shells of revolution with a nearly spherical middle surface and constant thickness. The solution is a procedure of successive corrections, used by Poisson for nonlinear differential equations and introduced into the analysis of thin shells by Burmistrov. The radius of the shell is described by a nearly constant function containing a dimensionless parameter. This parameter measures the maximum fractional deviation between the middle surfaces of the calotte shell and that of a representative spherical shell. The other dependent variables are developed in series of powers of the same parameter leading to a set of differential equations which admit theoretically feasible successive solutions.

THERMAL STRESSES IN THIN CYLINDRICAL SHELLS STIFFENED BY PLANE BULKHEADS FOR ARBITRARY TEMPERATURE DISTRIBUTIONS. Appendix - PREDICTION OF TRANSIENT TEMPERATURE DISTRIBUTIONS IN CYLINDER-BULKHEAD CONFIGURATIONS. D. J. Johns. Coll. of Aeronautics, Cranfield, Note No. 83, July, 1958. 23 pp. Development of a formula for the thermal stresses resulting near the joint of a cylinder and internal bulkhead due to arbitrary temperature distributions in the configuration and to the consequent forces and moments at the joint. The method is restricted in that the axial temperature variation in the shell must be a polynomial of positive order n less than, or equal to, three; but it is general enough to permit the inclusion of joint resistance. An approach for minimizing errors incurred in approximating any arbitrary temperature distribution to satisfy the above restriction is suggested.

ANALYSIS OF SHELLS OF REVOLUTION COMPOSED OF WORKHARDENING MATERIAL. E. T. Onat. J. Mech. & Phys. Solids, Nov., 1958, pp. 45-59. 14 refs. OOR-sponsored derivation of the yield criteria in terms of stress resultants of the shell and the rates of extension and curvature of the middle surface. The dependence of the yield criterion on the strain history and the mathematical problems of the analysis are discussed. Incipient plastic deformation of a cylindrical shell is treated as an example. The uniqueness of the incipient velocity field is discussed, and the dependence of the velocity rates on the rate of surface tractions is established for a simple case.

EFFECTS OF LOCAL LOADINGS ON PRESSURIZED CIRCULAR CYLINDRICAL SHELLS. Bertram Klein. Aircraft Eng., Dec., 1958, pp. 356-361. 31 refs. Analysis carried out to determine the deflections and stresses in the region of a localized loaded area subjected initially to internal pressure. Four types of loading are considered: uniform distributed radial loading, linearly distributed longitudinal bending moment, linearly distributed circumferential bending moment, and uniformly distributed tangential loading. Results are presented graphically for the first three cases and in tabular form in the last case.

THE STRAIN-ENERGY EXPRESSION FOR THIN ELASTIC SHELLS. J. H. Haywood and L. B. Wilson. (ASME Annual Meeting, New York, Nov. 30-Dec. 5, 1958, Paper 58 - A-25.) J. Appl. Mech., Dec., 1958, pp. 546-552. 19 refs. Derivation of an expression for an isotropic elastic shell in terms of the displacements of the middle surface of the shell. This expression is confined to small-deflection theory and the condition of plane stress, previously used in the theory of thin shells, is retained. A simplified expression is also obtained by the introduction of the Kirchhoff-Love hypothesis, and the relative merits of these two expressions are discussed.

AXIALLY SYMMETRIC BUCKLING OF SHALLOW SPHERICAL SHELLS UNDER EXTERNAL PRESSURE. E. L. Reiss. (ASME Annual Meeting, New York, Nov. 30-Dec. 5, 1958, Paper 58 - A-14.) J. Appl. Mech., Dec., 1958, pp. 556-560. Presentation of a simplified approach to the prediction of initial buckling loads based upon the solutions to two linearized versions of the original nonlinear problem. One of the linearized versions is an eigenvalue problem, while the other corresponds to the linear elasticity problem for the bending of a shallow spherical shell. A formula is obtained, yielding buckling loads that are in better agreement with experiments than previous approximate solutions to the nonlinear problem.

## Elasticity & Plasticity

THE PROBLEM OF TORSION AND PLANE STRAIN OF NON-HOMOGENEOUS PLASTIC BODIES. A. I. Kuznetzov. Arch. Mech. Stosowanej, No. 4, 1958, pp. 447-462. 13 refs. Investigation of (a) pure plastic torsion in the problem of a cylindrical bar subjected to torsion by moments acting at the ends, covering the case of rectilinear characteristics and that of the yield point varying in a certain direction; (b) elastic-plastic torsion in the problem of a circular bar. The case of slight inhomogeneities is considered, and some particular solutions are derived for the following cases: Cauchy problem for rectilinear boundaries, axisymmetric problems for a plane with circular holes, and the generalized Galin problem. The method of perturbation is used to derive the linear equations for additional stresses. The Prandtl problem is solved to illustrate the procedure and it is indicated that the stresses, velocities, slip lines, and the limit load can be determined in elementary form.

CRITERIA OF VALIDITY OF VARIATIONAL THEOREMS IN MECHANICS OF INELASTIC NON-HOMOGENEOUS ANISOTROPIC DEFORMABLE BODIES. W. Olszak and P. Perzyna. Arch. Mech. Stosowanej, No. 4, 1958, pp. 559-568. 10 refs. Analysis of the criteria of validity leading to the systematization of available theorems as well as to their generalization to the class of anisotropic bodies with rheological properties. Includes survey of previously developed theories, evaluation of their limitations, and establishment of the necessary conditions for the Weierstrass function.

## Plates

PLASTIC DEFORMATIONS OF ANNULAR PLATES UNDER DYNAMIC LOADS. Zenon Mróz. Arch. Mech. Stosowanej, No. 4, 1958, pp. 499-516. 12 refs. Study of the dynamics of an annular plate which is simply supported on the outer edge and subjected to the action of a uniform transverse load q or a shear force S on the internal periphery in order to determine the permanent end deflections. The load has, in function of time, the form of a rectangle. The assumption of the sectionally linear Coulomb-Tresca yield condition instead of the elliptic Huber-Mises condition leads to an effective integration of the equations of equilibrium. The model is assumed to be rigid-plastic without strain hardening and the equation of plastic flow is based on the existence of a plastic potential identical with the yield condition. A kinematic scheme analogous to that for a plate subjected to static deformation is also assumed for the case of medium loads.

## Testing Methods

FAIL-SAFE AND FATIGUE DEVELOPMENT OF THE PROP-JET TRANSPORT AIRPLANE. A. J. York. IAS 27th Annual Meeting, New York, Jan. 26-29, 1959, Rep. 59-20. 19 pp. Members, $0.50; nonmembers, $1.00. Discussion of fail-safe and fatigue objectives established for the Lockheed Electra, and description of the tests conducted to develop design information. These include tests to determine static strength of cracked material, strength of structural elements damaged from fatigue cracks or other sources, and crack propagation rates to evaluate inspection intervals. Fail-safe tests on a full scale wing box beam and full size fuselage panels are described. The fa-

tigue test program is summarized. Finally, results are presented on an extensive series of fail-safe damage tests conducted on the complete fuselage with the required flight and pressurization loads applied.

## Thermal Stress

THERMAL STRESSES IN TRANSVERSALLY ISOTROPIC BODIES. Z. Mossakowska and W. Nowacki. Arch. Mech. Stosowanej, No. 4, 1958, pp. 569-603. 11 refs. Investigation to determine the state of stress due to the action of a continuous and discontinuous temperature field in an elastic body showing transverse isotropy. The cases of an infinite space, a semispace, and an elastic layer are considered for steady as well as nonsteady temperature fields. A method of solution, based on the displacement function, is developed. It is assumed that the temperature field does not influence the mechanical properties of the elastic body, the system of coordinates is such that the three planes coincide with those of elastic symmetry, and the inertia forces are neglected for a nonsteady field.

RELIEF OF THERMAL STRESSES THROUGH CREEP. H. Poritsky and F. A. Fend. (ASME Annual Meeting, New York, Nov. 30-Dec. 5, 1958, Paper 58 - A-41.) J. Appl. Mech., Dec., 1958, pp. 589-597. Development of equations for extending tensile test stress-strain creep data to compound stresses by means of the Mises-Hencky hypothesis. The various equations are manipulated to yield a numerical procedure by which the stress and strain components are computed successively at the end of various time intervals. The resulting equations are applied to the axially symmetric problem of relief of thermal stresses in an infinitely long cylinder which is quickly heated to a parabolic temperature and maintained at that temperature. The calculation is reduced to repeated solutions of a certain second-order differential equation.

## Wings

LE ESTREME POSSIBILITA DI RESISTENZA DI UNA STRUTTURA ALARE. Ermenegildo Preti. L'Aerotecnica, Aug., 1958, pp. 227-233. In Italian. Study of the behavior of a wing structure in the presence of a vertical gust. The structure is considered to be rigid-plastic and such that plastic deformation may influence the distribution of aerodynamic and inertia loads along the span. The motion of the wing parts, due to the spanwise displacement of the plastic zone, is calculated by integrating a system of three ordinary differential equations of the first order. The cases of the trapezoidal and rectangular wing plan forms are considered. Conclusions indicate the necessity of considering the gust loads as a function of time and to give the wing such a distribution of resistant cross sections as to improve its strength beyond the elastic limit.

## THERMODYNAMICS

ON THE CALCULATION OF PROPERTIES OF GASES AT ELEVATED TEMPERATURES. I. Amdur and J. Ross. Comb. & Flame, Dec., 1958, pp. 412-420. 16 refs. ONR-supported discussion on the role of the potentials of intermolecular force in determining properties of gases at elevated temperatures. Three methods for determining these potentials are stated. The points emphasized are: the requirements for the calculation of accurate values of such properties, the extrapolation of potentials obtained from low temperature properties for calculation of high temperature properties, and the determination of the high temperature range where high energy molecular beam potentials are useful. The coefficients of viscosity and self-diffusion, isotopic reduced thermal diffusion ratios, and second virial coefficients for helium, argon, and nitrogen at 1,000°, 5,000°, and 15,000°K. are calculated for illustration purposes.

THERMODYNAMIC DESIGN OF SUPERSONIC EXPANSION NOZZLES AND CALCULATION OF ISENTROPIC EXPONENT FOR CHEMICALLY REACTING GASES. Rudolph Edse. USAF WADC TR 57-485 [AD 151184], July, 1958. 37 pp. Presentation of methods for calculating differential and integral values of the isentropic exponents in gases with the presence or absence of chemical reactions. A numerical evaluation is given for dissociating hydrogen. The results of the calculations indicate that the isentropic exponent of a chemically reacting gas mixture differs greatly from the ratio of the specific heats. This report indicates that accurate designs of supersonic expansion nozzles for chemically reacting gases require a detailed thermodynamic analysis of the system.

## Combustion

THE IGNITION OF COMBUSTIBLE MIXTURES BY HOT GASES. H. G. Wolfhard. Jet Propulsion, Dec., 1958, pp. 798-804. ONR-supported investigation of fuel-air mixtures ignited by a jet of hot gas which is heated in a ceramic furnace. The igniting gas is continuously injected into the cold explosive mixture. Luminous reactions can be seen to occur in the center of the hot jet if its initial temperature approaches a critical temperature. On further raising the temperature of the jet, the luminosity increases and a laminar luminous pencil extends up to 30 cm. above the furnace exit. Two types of experiments are performed: the ignition of cold fuel-air mixtures by hot neutral gases, such as nitrogen or carbon dioxide, and the ignition of cold fuel by hot air. In the second case only a diffusion flame can be ignited which, under favorable conditions, floats on top of the hot air jet. These "hot gas ignition temperatures" bear little relation to the "spontaneous ignition temperatures."

ACCELERATED FLAMES AND DETONATION IN GASES. H. Jones. Royal Soc. (London) Proc., Ser. A, Nov. 25, 1958, pp. 333-349. Analysis of the dynamics of accelerated flames in gases and the transition to detonation. It is shown that in the pre-detonation stage of an accelerated flame there is a fall in pressure and density behind the flame front, and that the gas velocity is in the opposite direction to the motion of the flame. Increasing

compression of the gas in front of the flame leads, after a time, to the development of a shock wave. The properties of this wave are calculated and it is proposed that detonation arises in this shock front which lies some distance ahead of the flame. The dynamics of the retonation wave, which is a shock wave thrown back into the hot gases at the onset of detonation, is examined and evidence is adduced to show that complete chemical reaction does not always occur in the front of an accelerated flame.

ON THE DECOMPOSITION FLAME OF LIQUID OZONE-OXYGEN MIXTURES IN A TUBE. R. Sandri. Comb. & Flame, Dec., 1958, pp. 348-352. 11 refs. Application of a flame propagation theory to a decomposition flame burning above a liquid ozone-oxygen mixture in a tube cooled externally with liquid oxygen. Neglecting heat losses to the wall, heat radiation, and heat conduction along the glass tube, flame velocities are computed for pressures of 1, 2 and 10 atmospheres for mixtures containing 50%, 75%, and 100% ozone. The results obtained for atmospheric pressure compare well with available experimental results.

MECHANISM AND KINETICS OF THE REACTION BETWEEN FUMING NITRIC ACID AND/OR ITS DECOMPOSITION PRODUCTS AND GASEOUS HYDROCARBONS. F. R. Taylor, R. G. Franklin, and O. N. Rudyj. USAF WADC TR 58-228 [AD 155550], Mar., 1958. 36 pp. 16 refs. Investigation of thermally induced explosions as a function of pressure, temperature, composition, and vessel size. Oscilloscope traces of the light emitted by the explosions indicate that two different modes of reaction are possible in this system: a short duration cool flame and a longer duration hot flame. A modified form of Semenoff's equation is used to relate minimum cool and hot flame ignition pressures to mixture composition and vessel size. Infrared analyses were made of the products of the cool and hot flame reactions, and conclusions are drawn on the interaction of the end products.

FLAME TEMPERATURE OF A SINGLE DROP OF LIQUID FUEL. M. A. Gurevich and V. B. Shteinberg. Sov. Phys. - Tech. Phys., Feb., 1958, pp. 368-375. Translation. Investigation to measure the maximum temperature in the combustion zone of a single drop. The measurements were carried out on a series of falling drops of identical size. The results have confirmed that the maximum temperature in the flame from a single drop is considerably lower than the value found from the diffusion theory. The difference amounts in any case to not less than 500°C. and is considerably larger when the oxygen content of the gaseous medium is high. Two considerations are used to explain the fact that the actual rates of evaporation of drops agree with the values calculated by the diffusion theory while the temperatures in the combustion region turns out considerably lower than values calculated. First, the diffusion theory does not take into account heat transfer by radiation; second, consideration of the finite rate of chemical reaction leads to practically the same calculated rates of evaporation, but a considerably lower flame temperature. The observed dependence of the flame temperature on the drop diameter would seem to indicate that the radiative heat transfer is of prime importance.

## Heat Transfer

ON THE HEAT TRANSFER COEFFICIENTS OF CYLINDRICAL BODIES. III. T. Tsubouchi and S. Sato. Tôhoku U. Rep. Inst. High Speed Mech., vol. 9, 1958, pp. 135-148. 15 refs. Measurement of local and mean heat-transfer coefficients of the vertical end surface and the horizontal cylindrical surface of a circular cylinder located in the still air by means of "the temperature boundary-layer method" together with the usual "heat quantity method." The results are expressed by experimental formulas on each part of the cylinder and are compared with conventional formulas for the vertical plate and the horyzontal cylinder.

HEAT TRANSFER AND REYNOLDS' ANALOGY IN A TURBULENT FLOW WITH HEAT RELEASE. R. R. Hunziker. ZAMP, Nov. 25, 1958, pp. 307-315. 23 refs. AFOSR-sponsored analysis using the Laplace transform to reduce the partial boundary value problem of temperature distribution in a circular duct to the general Sturm-Liouville boundary value problem. Using the Ritz method, corresponding eigenvalues and eigenfunctions can be calculated for various Prandtl and Reynolds Numbers. Temperature and heat-flow distribution along the wall are obtained.

SLIP-FLOW HEAT TRANSFER FROM CYLINDERS IN SUBSONIC AIRSTREAMS. L. V. Baldwin. US, NACA TN 4369, Sept., 1958. 77 pp. 25 refs. Measurement of heat-transfer coefficients for normal cylinders in air for Mach Numbers from 0.05 to 0.80, Reynolds Numbers from 1 to 75, and Knudsen Numbers from 0.009 to 0.077 at air temperatures between 0°F. and 280°F. and wire temperatures between 34°F. and 620°F. The measured Nusselt Numbers in this slip-flow experiment were extrapolated with good agreement to existing continuum-flow empirical relations at low Kn. The data qualitatively verified predictions of free-molecular flow theory at high Kn. Over 1,000 data points are tabulated and application of the results to hot-wire anemometry is discussed.

## VTOL & STOL

APERÇUS SUR CERTAINS PROBLEMES D'OPTIMISATION DES TRAJECTOIRES D'AERODYNES PAR LE CALCUL DE VARIATIONS. M. K. Bornemann. Tech. & Sci. Aéronautiques, Apr., 1958, pp. 67-70. In French. Survey of some problems of optimization for aerodyne trajectories using the calculus of variations. A method of solution is developed in order to eliminate certain limitations. Also described is a method based on the direct variation of incidence and thrust, using the integrand and the differential equation of motion.

*Mar. 17–20, 1958, Paper 58-AV-3.) Mech. Eng.*, Aug., 1958, pp. 54–56. Discussion of the role of failure-effect analyses in the design of aircraft.

**Simulated Service Life Testing. I, II.** Tibor Haas. *The Engr.*, Nov. 14; 21, 1958, pp. 754–756; 794–797. 18 refs. Discussion of a test method and equipment used by Bristol Aircraft for component fatigue testing.

**New Facility Tests Aircraft Systems in a Radiation Environment.** M. M. Miller and A. M. Liebschutz. *SAE J.*, Nov., 1958, pp. 38–41. Abridged.

### *Flight Testing*

**Measurements in Flight Testing of Aircraft by Electrical Means.** M. S. Narayanan. *Indian AF Quart.*, Apr.-June, 1958, pp. 35–54. Description of the component parts, operation, and advantages of the electrical system used for the measurement and recording of aerodynamic test data. Accelerometers, pressure pickups, and free and rate gyroscopes are discussed along with the electrical operating principles of transducers. Various types of airborne indicators and recorders are reviewed.

**Airborne Recorder and Computer Speed Flight-Test Data Processing.** A. T. Snyder. *ISA J.*, July, 1958, pp. 44–48. Description of a data handling system which produces completely processed data within 24 hours after flight test.

**The Free Flight Aerodynamics Range.** Appendix A—**Electronic Equipment.** Appendix B—**Survey of the Range Stations.** Appendix C—**List of Available Gun Tubes.** W. F. Braun. *U.S., BRL Rep. 1048*, July, 1958. 69 pp. Description of the range, and presentation of the operating techniques and associated experimental procedures used. The capabilities, limitations, and accuracy of the range are discussed.

**The Transonic Free Flight Range.** W. K. Rogers, Jr. *U. S., BRL Rep. 1044*, June, 1958. 64 pp. 24 refs. Description of the range, its instrumentation, and the experimental procedures associated with it.

**A Cure for Flight-Test Data Indigestion.** P. O. Lindfors. *ISA J.*, Sept., 1958, pp. 90–93. Description of the program for the integrated data acquisition and processing system Project DATUM used in flight testing of modern military aircraft.

### *Rocket Sleds, Tracks*

**Vibration Isolation of High-Speed Track Vehicles.** J. C. Burgess. *USAF FTC TR 58-19* [*AD 152143*], Apr., 1958. 52 pp. Development of criteria for the design of resilient slipper mounts for high-speed track vehicles. The program includes an investigation of the vibration environment of track vehicles and development of prototype isolators.

### *Wind Tunnels*

**Hydraulics in a Supersonic Wind Tunnel.** J. Grindrod. *Appl. Hydraulics & Pneumatics*, Nov., 1958, pp. 120–122. Description of hydraulic equipment used to regulate the size and shape of a wind tunnel nozzle and diffuser section.

**Transient Analysis of a Two-Chamber Blowdown Process with Critical Flow.** C. F. Dewey, Jr. *J. Aero/Space Sci.*, Jan., 1959, pp. 62, 63. Simplified analysis of the transient conditions existing in a supply tank of given initial pressure and a second tank or receiver which, in turn, discharges to the atmosphere. Results for the limiting case of small transient times are derived in closed form.

**Pressure Fluctuations in a Blowdown Wind Tunnel.** J. S. Murphy. *J. Aero/Space Sci.*, Jan., 1959, pp. 61, 62. Presentation of measurements of the pressure-fluctuation level in the stilling chamber and test section before and after installation of the muffler.

**Electric Arc Gas Heaters for Re-Entry Simulation and Space Propulsion.** (*ARS 13th Annual Meeting, Nov. 17–21, 1958.*) *Avco Res. Lab. RR 35*, Sept., 1958. 29 pp. Development and calibration of an arc-powered wind tunnel designed to provide steady flow simulation of the conditions encountered during re-entry. Flight velocities between 16,800 and 21,800 ft./sec. can be simulated by this device.

**High-Speed Multiple-Spark Light Source.** M. R. Wilson and R. J. Hiemenz. *Rev. Sci. Instr.*, Nov., 1958, pp. 949–951. Description of a device which can be used in the photographic systems of shock tunnels, shock tubes, and ballistic ranges.

**Notes on Wind Tunnel Pressure Measurements from Operator's Point of View.** J. S. Thompson and D. W. Holder. (*NATO AGARD Wind-Tunnel & Model-Testing Panel, London, Mar. 24–28, 1958.*) *NATO AGARD Rep. 164*, Mar., 1958. 59 pp. 40 refs.

**Automatic Data Reduction Equipment for Wind Tunnels.** Appendix I—**Detailed Operation of the Typewriter.** Appendix II—**Detailed Operation of the Card Punch Buffer Circuit.** Appendix III—**Detailed Operation of the Scanner.** Appendix IV—**Detailed Operation of the Serial Counter.** Appendix V—**Detailed Operation of the Hand Set Switch Unit.** G. C. Rowley. *Gt. Brit., ARC CP 399* (May, 1957) 1958. 49 pp. BIS, New York, $1.17.

**Digital Recorder for Wind-Tunnel Data.** R. C. Macarthur and W. J. Ungar. *Electronics*, Dec. 5, 1958, pp. 86–89. Description of the operation, performance, and application of the digital recorder.

**Performance Estimates for the R.A.E. 6 inch High Pressure Shock Tube.** Appendix—**Properties of Driver Gas Produced by $H_2$–$O_2$ Combustion.** B. A. Woods. *Gt. Brit., RAE TN Aero. 2560*, May, 1958. 52 pp. 15 refs. Presentation of performance calculations made with various driver gases over a range of pressure ratios giving shock Mach Numbers from 6 to 22. Results are presented in graphical form.

**Helium Tunnel Tests High-Speed Models.** *G-E Rev.*, July, 1958, pp. 16, 17. Discussion of the use of helium gas in wind tunnels.

## Rotating Wing Aircraft, Helicopters

**YH-32 Limited Performance and Stability.** J. S. Hayden and W. R. Lake. *USAF FTC TR 58-23* [*AD 152147*], June, 1958. 48 pp. Results of tests made to determine the performance of rotor-tip-mounted ram-jet power plants and to define stability and control characteristics of the paddle-controlled rotor.

**XH-40 Air Force Flight Evaluation.** V. K. Putnam and R. G. Ferry. *USAF FTC TR 58-15* [*AD 152136*], May, 1958. 108 pp. Preliminary test results for a turbine-powered helicopter showing the need for improvement in the lateral-directional stability and control force systems.

**The VERTOL 107.** *AHS Newsletter*, Sept., 1958, pp. 2–8. Discussion of design characteristics and possible military applications of a twin-turbine helicopter.

**HU-1 Iroquois.** Harvey Gaylord. *AHS Newsletter*, Oct., 1958, pp. 2–10. Design, performance, maintenance, and flight characteristics of the HU-1 Iroquois. The test and development programs are also described.

**The Turbine Helicopter.** D. L. H. Williams. *Helicopter Assn. Gt. Brit. J.*, Oct., 1958, pp. 213–229; Discussion, pp. 229–237. Discussion of the development of the Westland Wessex and Westminster helicopters.

**Development and Flight Tests of an Instrument Flight Director for Helicopters.** Appendix—**Pilots' Assessment of System.** P. Brotherhood. *Gt. Brit., ARC CP 390* (Aug., 1957) 1958. 22 pp. BIS, New York, $0.63.

**The Helicopter and Its Engine.** *de Havilland Gazette*, Aug., 1958, pp. 135–137. Discussion of special considerations involved in the use of gas turbine power plants in helicopters, in particular, the advantages of a high power/weight ratio.

**Assessing Rotor Drive Efficiency.** A. R. Weyl. *Aeronautics*, Dec., 1958, pp. 38–40. Survey of the merits of various helicopter propulsion systems, and discussion of the cooling of gas turbine blades.

**Natural Vibration Frequencies of Flexible Rotor Blades; A Method Based on Consideration of Perfectly Flexible Blades.** J. L. Taylor. *Aircraft Eng.*, Nov., 1958, p. 331.

**Cold Jet Cycle Helicopters.** P. H. L. Morain (*AHS 14th Annual Natl. Forum, Wash., Apr. 17, 18, 1958.*) *AHS J.*, Oct., 1958, pp. 12–19. Discussion of rotor and engine power requirements, thermal losses, pressure drop, and propulsion efficiency. Results are analyzed and factors such as forward speed, fuel consumption, and noise problems are considered.

**An Evaluation of the Jet Rotor Helicopter.** H. R. Velkoff. (*AHS 14th Annual Natl. Forum, Wash., Apr. 17, 18, 1958.*) *AHS J.*, Oct., 1958, pp. 3–11. 35 refs. Review of the developmental history of jet rotors. Comparisons of jet schemes with other drive systems are made on the basis of predicted and actual capability.

**The Efficiency of the Radial Outflow Turbine (with Special Reference to the Helicopter Pressure Jet Propulsion System).** J. B. Nichols. *AHS J.*, July, 1958, pp. 42–45. Establishment of a standard definition of pure reaction radial outflow turbine efficiencies. Pressure jets with and without tip burning are considered.

**Interchangeable Rotor-Blades.** J. P. Kushnerick. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 36–41. Description of the fabrication of interchangeable helicopter rotor-blades. Bonding procedure and strength are discussed.

**Direct Analog Method of Analysis of the Vertical Flight Dynamic Characteristics of the Lifting Rotor with Floating Hub.** R. H. MacNeal. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 806.*) *AHS J.*, Oct., 1958, pp. 35–49. 12 refs.

**Analysis of the Vertical Flight Dynamic Characteristics of the Lifting Rotor with Floating Hub and Off-Set Coning Hinges.** Appendix I—**Remarks on Two-Degree-of-Freedom Analysis.** Appendix II—**Remarks on the Three-Degree-of-Freedom Analysis.** Appendix III—**Effect of Rotor Support System on the Damping in the Flutter Mode.** Appendix IV—**Damping of the Helicopter in Pitch and Roll.** K. H. Hohenemser and C. H. Perisho. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 820.*) *AHS J.*, Oct., 1958, pp. 20–34.

**On the Determination of the Chordwise Bending Frequencies of Rotor Blades.** G. W. Brooks. *AHS J.*, July, 1958, pp. 40–42.

**Pitch-Lag Instability of Helicopter Rotors.** Pei Chi Chou. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 805.*) *AHS J.*, July, 1958, pp. 30–39.

**Wind-Tunnel Tests of a Full-Scale Helicopter Rotor with Symmetrical and with Cambered Blade Sections at Advance Ratios from 0.3 to 0.4.** J. L. McCloud, III, and G. B. McCullough. *U. S., NACA TN 4367*, Sept. 1958. 33 pp.

## Safety

**Investigation of Fires Originating from an Aircraft Oxygen System.** P. R. Dierdorf. *U.S., CAA TDR 327* (*OTS PB 131730*, $0.50), Mar., 1958. 5 pp.

## Space Travel

**Space Travel—Scientific Frontier.** Ross Fleisig. *Sperryscope*, 2nd Quart., 1958, pp. 6–9. Brief historical survey of space travel, and discussion of the importance of space exploration and of some rocket aircraft research programs.

**Special Issue: Space Vehicles, Satellites, and Missiles—A Symposium.** (*AIEE Summer Gen. Meeting & Air Transp. Conf., Buffalo, June 22–27, 1958.*) *Elec. Eng.*, Dec., 1958, pp. 1,077–1,092; Discussion, pp. 1,092–1,095. 10 refs. *Partial Contents:* The Motions of Satellites, I. M. Levitt. Space-Flight Guidance, C. S. Draper. Dynamic Stabilization in Large Rocket Vehicles, R. E. Hanna. Attitude Control, I, J. S. Farrior. Attitude Control, II, R. E. Roberson. Attitude Control, III, D. B. De Bra and E. V. Stearns. System Design, J. L. Bowers.

**The Actual Shape of the Earth as Applied to Celestial Mechanics.** P. H. Savet. *ARMA Eng.*, July-Aug., 1958, pp. 18–23. Tentative analysis of a few basic facts of Satellite dynamics.

**A Survey of Propulsion and Space Dynamics.** D. B. Cross and Jorgen Jensen. (*AAS 4th Annual Meeting, New York, Jan. 29–31, 1958, Preprint 57–1.*) *J. Astron. Sci.*, Spring, 1958, pp. 15–19, 30. 20 refs. Discussion of some factors influencing the design of space vehicles.

**Designing a Mars Probe Computer.** C. F. O'Donnell. *Space/Aeronautics*, Dec., 1958, pp. 182–192. Detailed analysis of a hypothetical mission describing the functions, the required accuracy, speed, and reliability of computers in space.

**Optical Determination of Orientation and Position Near a Planet.** R. E. Roberson. (*ARS Semi-Annual Meeting, Los Angeles, June 9–12. 1958.*) *Jet Propulsion*, Nov., 1958, pp. 747–750.

**Project Snooper, A Program for Unmanned Interplanetary Reconnaissance.** M. I. Willinski and E. C. Orr. (*ARS Spring Meeting, Wash., Apr. 4–7, 1957.*) *Jet Propulsion*, Nov., 1958, pp. 723–729. Description of a nonreturn, nuclear powered ion rocket propelled reconnaissance vehicle weighing 3,300 lbs. A vehicle weight statement, drawings, and a description of a possible missile trajectory are included.

**Reconnaissance Orbits.** Appendix I—**Assumptions and Outline of Method of Calculation.** Appendix II—**Considerations of Extreme Points on Curves.** S. W. Greenwood. *Brit. Interpl. Soc. J.*, Sept.-Oct., 1958, pp. 534–537. Discussion on the importance of reconnaissance orbits for future space exploration. Data for journeys inside and outside the Earth's orbit are given in graphical form.

**Earth Satellite Photogrammetry.** Paul Rosenberg. *Photogrammetric Eng.*, June, 1958, pp. 353–360. Discussion of photogrammetry of the earth's surface from satellites, manned and unmanned. Orbits, satellite-borne photographic cameras, and environmental conditions are considered. A brief discussion of television and other electronic ground scanning methods from a satellite is made.

**Measurement of Satellite Erosion Rates by the Backscattering of Beta-Rays.** R. C. Goetteiman. *Jet Propulsion*, Nov., 1958, pp. 753–756. Description of a method to measure thickness changes using beta-ray backscattering phenomena.

**Motion of a Satellite with Friction.** L. N. Persen. *Jet Propulsion*, Nov., 1958, pp. 750–752. Presentation of two examples of satellite motion under the action of frictional forces.

**Torques on a Satellite Vehicle from Internal Moving Parts.** R. E. Roberson. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–39.*) *J. Appl. Mech.*, June, 1958, pp. 196–200. Derivation of a complete expression for the attitude perturbation torque arising from the motion of internal parts. The attitude reference coordinate system is discussed and the nature of the torque for three simple cases is found.

**The Influence of the Launching Conditions on the Orbital Characteristics.** G. S. Gedeon and R. E. Dawley. *Jet Propulsion*, Nov., 1958, pp. 759, 760. Calculation of the relationship between the apogee and perigee altitude and the burnout conditions from the equations of motion of a satel-

lite orbiting in a vacuum around a spherical nonrotating earth.

**Sputnik I's Last Days in Orbit.** J. D. Kraus and E. E. Dreese. *IRE Proc.*, Sept., 1958, pp. 1,580–1,587. 15 refs. Presentation of observations made during the last days of Sputnik I's orbiting. Graphs of the average height of the satellite and its associated fragments as a function of time are given, and some conclusions are drawn as to the details of the actual breakup phenomenon.

**L'Astronautica.** Glauco Partel. *Riv. Aero.*, Aug., 1958, pp. 1,137–1,162. In Italian. Discussion of the basic aspects of interplanetary flight, including such problems as flight to the moon, space stations, and propulsion. Also presented are tables of planets and satellites of the solar system, as well as characteristic velocities for interplanetary missions covering various types of propulsion.

**Recent Advances in Astrodynamics.** R. M. L. Baker, Jr. *Jet Propulsion*, Oct., 1958, pp. 649–654. 38 refs. Survey of research on perturbation theory, nongravitational forces, determination of orbits, coordinate systems, and astronomical and gravitational constants.

**What is the Purpose?** J. de Groot. *Avia Vliegwereld*, Aug. 14, 1958, pp. 494–496. Discussion of the use of artificial satellites, such as measurement and observation of cosmic and ultraviolet sun radiation.

**The Next Steps.** M. Vertregt. *Avia Vliegwereld*, Aug. 14, 1958, pp. 486–488, 491. Investigation on the next aims of space flight, such as the launching of a manned satellite and the solution of the re-entry problem.

**Space Flight and Relativity.** J. M. J. Kooy. *Avia Vliegwereld*, Aug. 14, 1958, pp. 472–475. Theoretical analysis of the importance of time dilatation for space flight in the near future.

**Optimum Paths to the Moon and Planets.** A. E. Bryson and G. A. Ouellette. *Astronautics*, Sept., 1958, pp. 18–21, 80–82. Study of Hohmann ellipses for traveling between the Earth and Mars and of the necessary modifications of this path for Earth-Moon travel.

**Energy Sources for Space Travel.** J. Geertsma. *Avia Vliegwereld*, Aug. 14, 1958, pp. 476, 477. Evaluation of various propulsion systems for space flight, such as electron hull, nuclear, annihilation, and solar energy.

"PONY POWER" MOTORS

*that give stamina to your products*

Lamb Electric ***fractional*** horsepower motors, like the small horses of the famed western-pioneer-day Pony Express, are developed for *stamina.*

Their dependability, and efficiency (optimum weight-size-horsepower ratio) are qualities that result from proper design and careful manufacture by personnel with many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages—and also perhaps lower costs—to *your* products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

*Lamb Electric*
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Radar voltage regulator gear motor.

A rugged high-torque, high-speed motor.

Motor with efficient spur gear speed reducer.


**Some Problems of Space Navigation.** R. E. Roberson. (*IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958.*) *Aero/Space Engrg.*, Dec., 1958, pp. 39–43, 54. 14 refs. Discussion of three requirements of guidance design and their interrelationship. These are functional requirements, performance requirements, and physical considerations. A functional program is suggested for attacking the requirement problems.

**The First Space Ship.** Martin Caidin. *Astronautics*, July, 1958, pp. 35–37, 75–77. Description of the X-15 rocket vehicle, and discussion of its development program.

**Rundown on Jupiter-C.** Wernher von Braun. *Astronautics*, Oct., 1958, pp. 32, 33, 80, 82–84. Description of the Jupiter-C configuration and its operation in placing a satellite into orbit.

**Synodic Satellites.** W. B. Klemperer and E. T. Benedikt. *Astronautics*, Oct., 1958, pp. 28, 29, 64, 66, 68. Discussion of conditions under which a satellite could be established in such an orbit that it would remain in equilibrium in a constant relationship with both the earth and the moon.

**Special Issue: A Discussion on Observations of the Russian Artificial Earth Satellites and Their Analysis.** *Royal Soc. (London) Proc., Ser. A*, Oct. 28, 1958, pp. 1–87. 19 refs. *Contents:* Observations at the Mullard Radio Astronomy Observatory, Cambridge, M. Ryle. Interferometer Measurements on the First Satellites, A. N. Beresford. Observations on the U.S.S.R. Earth Satellite Radio Signals, H. V. Griffiths. Radar Observations of the Russian Earth Satellites and Carrier Rocket. Centimetric Radar Observations of the Russian Satellites, J. S. Hey and V. A. Hughes. Method for Computations of Satellite Orbits, L. Jacchia. The Prediction Service of H. M. Nautical Almanac Office, D. H. Sadler. The Computation of Orbit Parameters from Interferometer and Doppler Data, E. G. C. Burt. Perturbations of the Orbit of a Satellite Near to the Earth, D. G. King-Hele. Direction-Finding Observations on the 20 Mc/s Transmissions from the Artificial Earth Satellites, F. A. Kitchen. Radio Observations on 20 and 40 Mc/s, W. C. Bain. Post Office Observations on the First Russian Satellite, C. F. Booth. The Ionosphere and the Radio Emission from the Satellites, K. Weekes. The Rocket's Dimensions, R. d'E. Atkinson. The British Astronomical Association's and Radio Society of Great Britain's Earth Satellite Observations, J. Heywood.

**Visual and Photographic Observation of Artificial Satellites.** C. de Jager. *Avia Vliegwereld*, Aug. 14, 1958, pp. 492, 493, 496. Description of visual and telescopic observation methods and of instruments used for accurate satellite tracking.

**Keeping Track of Earth Satellites.** C. J. Sletten, G. R. Forbes, Jr., and L. F. Shodin. *Electronics*, Oct. 10, 1958, pp. 81–83. Description of an interferometer system consisting of a dual-terminal array of 22 dipoles proximity-coupled to a two-wire line.

**Orbits of Satellites.** J. F. Babcock. *Air U. Quart. Rev.*, Spring, 1958, pp. 113–144. Presentation of fundamentals in analytic geometry concerning conic section formulas to assist in understanding missile trajectories, together with the laws of physics and concepts of astronomy for orbiting.

**Satellite Orbit Perturbations Under a Continuous Radial Thrust of Small Magnitude.** A. Dobrowolski. *Jet Propulsion*, Oct., 1958, pp. 687–689.

**The Effect of the Earth's Oblateness on the Orbit of a Near Satellite.** D. G. King-Hele. (*Gt. Brit., RAE TN G.W. 475*, Oct., 1957.) *Royal Soc. (London) Proc., Ser. A*, Sept. 9, 1958, pp. 49–72. 15 refs.

**First Earth-Scanning Satellite.** J. P. Kushnerick and S. P. Kaprielyan. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 30–32. Description of a weather scanning satellite capable of mapping vast areas of the Earth's cloud cover.

**U. S. Designs Infrared-Scanner Satellite.** J. A. Fusca. *Av. Week*, Aug. 18, 1958, pp. 82–84, 87.

**Preliminary Results of Satellites 1958 Alpha and 1958 Gamma.** Hugh Odishaw. *News Rep.*, May-June, 1958, pp. 41–44.

**Satellite Controls Pose Major Problems.** R. L. Sweeney. *Av. Week*, Aug. 25, 1958, pp. 37–43. Discussion of the various problems of satellite control, propulsion systems, and human factors.

**Vanguard Control Demonstrates Minimum Hardware Approach. II.** R. H. Cushman. *Auto. Control*, July, 1958, pp. 16–20.

**The "Explorers."** Wernher von Braun. *The Engr.*, Sept. 5, 1958, pp. 372–375. Description of the firing procedure for Jupiter-C, the instrumentation carried by the first satellite, and some preliminary results of data gathered by the satellite.

**Contributions of the Explorer to Space Technology.** J. E. Froehlich. (*IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958.*) *CIT Jet Propulsion Lab. EP 526*, July 7, 1958. 24 pp. Discussion of the launching vehicle and satellite, together with some preliminary measurements and their significance.

## Structures

**On the Analysis of Complex Elastic Structures.** J. H. Argyris. *Appl. Mech. Rev.*, July, 1958, pp. 331–338. 103 refs. Review of recent work on relaxation and matrix methods.

**Einschliessung von Eigenwerten und Mohrsches Spannungsdiagramm.** Erwin Kreyszig. *ZAMP*, Sept. 25, 1958, pp. 202–206. In German. Presentation of a new proof of a theorem by Wielandt for inclusion of eigenvalues of Hermitian matrices. Relations between that inclusion method and the Mohr stress diagram are investigated.

**General Theory of Buckling.** H. L. Langhaar. *Appl. Mech. Rev.*, Nov., 1958, pp. 585–588. 69 refs. Discussion on various aspects of the buckling theory, such as bifurcation and energy concepts.

**Structures et Chaleur aux Vitesses Supersoniques et Hypersoniques.** B. Dorleac. (*NATO AGARD 6th Structures & Materials Panel, Paris, Nov. 4–8, 1957.*) *NATO AGARD Rep. 149*, Nov., 1957. 99 pp. In French. Analysis of some structural problems and design types investigated in France during the last few years, and enumeration, with some details, of structural problems of the future.

### Bars & Rods

**Prodol'nyi Izgib Sterzhnia za Predelom Uprugosti.** I. S. Maliutin. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 112–116. In Russian. Derivation of a solution for previously derived equations describing the behavior of longitudinally clamped bars beyond the elasticity limit assuming the absence of secondary plastic deformations.

### Beams & Columns

**Krucheuie Kruglogo Brusa s Dvumia Vrezami.** E. A. Shiriaev. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 549–553. In Russian. Study of the torsion of notched circular beams by means of conformal mapping.

**Plate Girder Design; Flange Stiffness and Web Plate Behaviour.** K. C. Rockey. (*Engineering*, Dec. 20, 1957.) *ADA Res. Rep. 37*, Jan., 1958. 12 pp. 26 refs. Reprint.

### Connections

**The Behaviour of Metal Bonded Joints.** Karl Wellinger and Ulrich Rembold. (*VDI Zeitschrift*, No. 2, 1958, pp. 41–46.) *Gt. Brit., RAE Lib. Transl. 771*, Sept., 1958. 14 pp. 13 refs.

### Cylinders & Shells

**Design of a Thin-Walled Cylindrical Pressure Vessel Considering Plasticity.** Joseph Marin and M. G. Sharma. (*ASME-AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J. Res. Suppl.*, Nov., 1958, pp. 515-s–519-s. Abridged. Calculation of the wall thickness considering the plastic stress-strain behavior and the so-called "instability" or maximum pressure that can be produced in the vessel.

**Plastic Design of Thick-Walled Pressure Vessels.** Joseph Marin and F. P. J. Rimrott. *Welding J. Res. Suppl.*, Dec., 1958, pp. 570-s–576-s. 22 refs. Critical review of methods used for determining the strength of thick-walled cylinders subjected to internal pressure. Experimental results are evaluated, and a new theory providing a simple approximate design formula is proposed.

**General Instability of Ring-Stiffened Cylindrical Shells Subject to External Hydrostatic Pressure—A Comparison of Theory and Experiment.** G. D. Galletly, R. C. Slankard, and E. Wenk, Jr. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-73.*) *J. Appl. Mech.*, June, 1958, pp. 259–266. 23 refs.

**Displacement and Rotation at the Junction of Two Cylinders of Unequal Thickness Due to Axisymmetrical Loadings.** G. D. Galletly. *J. Aero/Space Sci.*, Jan., 1959, pp. 60, 61.

**Plasticheskie Deformatsii Truby pri Osesimmetrichnoi Nagruzke.** A. R. Rzhanitsyn. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 60–65. In Russian. Analysis of the critical state of cylindrical shells, including derivation of a simple differential equation for the deformation of cylindrical shells subjected to axisymmetrical loading, as well as a graphical representation for the case of stability.

**Primenenie Odnogo Variatsionnogo Metoda k Raschetu Konicheskikh Obolochek.** A. N. Elpat'evskii and B. A. Konovalov. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 106–111. In Russian. Application of a variational method to the calculation of conical shells.

**Ob Ustoichivosti Trekhsloinoi Pologoi Tsilindricheksoi Obolochki pri Szhatii.** L. M. Kurshin. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 97–100. 10 refs. In Russian. Study of the stability of cylindrical sandwich shells subjected to compressive loads.

**K Teorii Neodnorodnykh zotropnykh Obolochek.** E. L. Aksel'rad. *AN SSSR Otd. Tekh. Nauk Izv.*, June, 1958, pp. 73–76. In Russian. Evaluation of the applicability of the theory on homogeneous shells to the case of inhomogeneous isotropic shells.

**The Onset of Yield in a Thick Spherical Shell Subject to Internal Pressure and Uniform Heat Flow.** M. G. Derrington and W. Johnson. *Appl. Sci. Res., Sect. A*, No. 6, 1958, pp. 408–420. Determination of the onset of yield due to temperature and pressure. Results are derived in nondimensional form and a chart defining the regions in which yield first occurs is presented. The criterion of optimum temperature for greatest "stress-saving" is established.

### Elasticity & Plasticity

**Plasticity of Solids Explored by New Technique.** J. J. Gilman. *G-E Rev.*, July, 1958, pp. 9–12. Study of the effect of dislocation motion of the mechanical properties of metals.

**Diffusive Creep of Solids.** B. Ia. Pines. *Sov. Phys.-Tech. Phys.*, Oct., 1957, pp. 2,149–2,155. Translation. Analysis of the diffusive creep phenomenon occurring in solids. In the presence of a gradient in one of the principal normal stresses, there occurs a "directed self-diffusive" flow of atoms corresponding to creep, just as in the case of a gradient in the overall pressure.

**Elastic Wave Scattering at a Cylindrical Discontinuity in a Solid.** Appendix—**Relations Between Scattered Waves Undergoing Mode Conversion.** R. M. White. *ASA J.*, Aug., 1958, pp. 771–785. 20 refs. ONR-supported analysis of the scattering of plane compressional and shear elastic waves obliquely incident on an infinitely long cylindrical discontinuity in an isotropic solid.

**On Isoperimetric Inequalities in Plasticity.** Walter Schumann. *Quart. Appl. Math.*, Oct., 1958, pp. 309–314. 10 refs. Presentation of a proof for the inequality $P \geq 6\pi M_0$, where $P$ is the total limit load, $M_0$ the yield moment of a thin, perfectly plastic, simply supported, uniformly loaded plate of arbitrary shape and connection.

**Otsenka Tochnosti Printsipa Sen-Venana pri Rastiazhenii Anizotropnoi Polosy.** A. S. Kosmodamianskii. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 130–133. In Russian. Evaluation of the accuracy of Saint Venant's principle in the case of anisotropic plates subjected to tension, using the mixed variational method.

**Extension of Michell's Theorem to Problems of Plasticity and Creep.** Bernard Budiansy. *Quart. Appl. Math.*, Oct., 1958, pp. 307–309. Analysis showing that the independence of the elastic value of Poisson's ratio, as stated by Michell, holds under the same conditions even when plastic flow and creep occur.

**K Voprosu o Metode Resheniia Nekotorykh Uprugo-Plasticheskikh Zadach.** K. N. Shevchenko. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 152–155. In Russian. Evaluation of a method for the solution of certain elasto-plastic problems covering the case of a half-plane subjected to concentrated loading.

**A Compressible Elastic, Perfectly Plastic Wedge.** D. R. Bland and P. M. Naghdi. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-38.*) *J. Appl. Mech.*, June, 1958, pp. 239–242. ONR-sponsored analysis of a compressible elastic-plastic wedge of an included angle $\beta < \pi/2$ in the state of plane strain. The solution is compared with that of an incompressible elastic-plastic wedge in one case($\beta = \pi/4$) for various positions of the elastic-plastic boundary.

**On Plane Stress Solution of an Elastic, Perfectly Plastic Wedge.** P. M. Naghdi. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-40.*) *J. Appl. Mech.*, Sept., 1958, pp. 407–410. Application of Tresca's yield function and its associated flow rule to obtain a solution for a wedge subjected to a uniform traction in the state of stress.

**O Razryvnykh Resheniiakh Prostranstvennykh Zadach Teorii Ideal'noi Plastichnosti.** D. D. Ivlev. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 480–486. In Russian. Analysis covering the discontinuous solutions of spatial problems in the theory of ideal plasticity for a specific case.

**O Predstavlenii Obshchego Resheniia Osnovnykh Uravnenii Staticheskoi Zadachi Teorii Uprugosti Izotropnogo Tela pri Pomoshchi Garmonicheskikh Funktsii.** V. I. Blokh. *Prikl. Mat. i Mekh.*, July-Aug., 1958, pp. 473–479. In Russian. Derivation of a general solution for the basic equations of the static problem in the theory of elasticity for the case of isotropic bodies, using harmonic functions.

**An Experimental Study of Initial and Subsequent Yield Surfaces in Plasticity.** P. M. Naghdi, F. Essenburg, and W. Koff. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-37.*) *J. Appl. Mech.*, June, 1958, pp. 201–209. 14 refs. OOR-sponsored presentation of experimental results for 25 tubular specimens of a 24S-T-4 aluminum alloy, subjected to combined torsion-tension-reversed torsion, and of two additional specimens subjected to tension followed by torsion for comparison purposes.

**On the Simplification of the Nonlinear Integral Equations of Slip and Relaxation for a Complex State of Stress.** M. I. Rozovksii. *Sov. Phys.–Tech. Phys.*, Dec., 1957, pp. 2,590, 2,591. Translation.

**Propagation in an Infinite Elastic Plate.** J. W. C. Sherwood. *ASA J.*, Oct., 1958, pp. 979–984. 15 refs. Analysis that establishes the existence of an infinite number of eigenmodes of vibration possessing complex propagation constants. The asymptotic low-frequency behavior of each mode has been determined and found to be independent of the Poisson's ratio of the plate material.

**O Plasticheskom Techenii v Tonkom Sloe.** O. A. Monastyrskii. *AN SSSR Otd. Tekh. Nauk Izv.*, June, 1958, pp. 107–110. In Russian. Derivation of a solution for the case of plastic flow in a thin layer of incompressible material.

**The Propagation of Stress Waves in Viscoelastic Solids.** Herbert Kolsky. *Appl. Mech. Rev.*, Sept., 1958, pp. 465–468. 60 refs. Survey of theoretical and experimental work on stress wave propagation.

**Ob Ustoichivosti Trekhsloinykh Obolochek i Plastin za Predelom Uprugosti.** E. I. Grigoliuk. *AN SSSR Otd. Tekh. Nauk Izv.*, June, 1958, pp. 68–72. In Russian. Application of previously obtained results to study the stability of sandwich plates and shells beyond the elasticity limit.

**Analyses for Diffusion During Plastic Deformation.** J. Simmons and J. E. Dorn. *J. Appl. Phys.*, Sept., 1958, pp. 1,308–1,313. USAF-supported development of a general equation for self-diffusion in deforming media. Methods of analysis for determining the self-diffusivity as a function of time for prescribed strain histories are given for special cases of linear diffusion.

**Theoretical and Experimental Investigation on Friction-Lines of Elliptic Plates in Plastic Compression.** Liu Shu-I and Wang Ming-Tzong. *Acta Metallurgica Sinica*, Dec., 1957, pp. 349–365. In Chinese, with summary in English.

**Thermoelastic Dissipation Due to High-Speed Dislocations.** J. H. Weiner. *J. Appl. Phys.*, Sept., 1958, pp. 1,305–1,307. AFOSR-supported calculation of the thermoelastic dissipation due to an edge dislocation moving at an arbitrary speed. It is found that at usual strain levels this mechanism has only a minor effect in limiting dislocation speed.

### Fatigue

**Some Proposals for Evaluating Fatigue Properties of Airplane Structures.** K. O. Lundberg. (*2nd Europ. Aero. Congr., Scheveningen, Sept. 25–29, 1956.*) *Sweden, Flygtekniska Försöksanstalten, FFA Medd. 76*, 1958. 36 pp. 29 refs. Discussion of a definition for the unit load-spectrum period and the expression of spectrum fatigue life in terms of a spectrum life multiple, defined as the number of times that the unit spectrum period is repeated. Methods are then presented for the design of a structure for a required spectrum life.

### Plates

**Further Large-Deflection Analysis for a Plate Strip Subjected to Normal Pressure and Heating.** M. L. Williams. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-14.*) *J. Appl. Mech.*, June, 1958, pp. 251–258. Extension of the large-deflection analysis and design charts to the case where the temperature distribution through the thickness of the plate may have any desired distribution.

**Bending of Elastically Restrained Rectangular Plates Under Uniform Pressure.** C. L. Kantham. *RAeS J.*, Nov., 1958, pp. 834–836. Analysis of the bending problem for plates elastically restrained against rotation performed by superposition of moments on a loaded simply-supported plate following the Timoshenko approach.

**On the Post-Buckling Behaviour of Stiffened Plane Sheet Under Shear.** E. H. Mansfield. *Gt. Brit., ARC R&M 3073* (Nov., 1952) 1958. 21 pp. BIS, New York, $1.35. Presentation of formulas and graphs for the rapid determination of shear stiffness, shear strain, and induced compressive stresses in stringers and frames.

**Some Solutions of the Timoshenko Beam Equation for Short Pulse-Type Loading.** H. J. Plass, Jr. (*ASME West Coast Conf. Appl. Mech. Div., Los Angeles, Sept. 8–10, 1958, Paper 58–APM-3.*) *J. Appl. Mech.*, Sept., 1958, pp. 379–385. Analysis for various types of support conditions and impact conditions, considering the impact to be a pulse in the form of a half-sine wave. The results are found numerically, using the method of characteristics, except for one case, which was done in addition by the Laplace transform method for verification purposes.

**Bol'shie Progiby Priamougol'noi Membrany, Podkreplennoi Uprugim Rebrom.** N. S. Kurdin. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 117–119. In Russian. Derivation of a solution for the nonlinear problem of rectangular membranes on elastic supports.

**Elementary Solution of Some Plate Problems.** Václav Vodička. *ZAMP*, Sept. 25, 1958, pp. 206–210. Analysis of the bending problem of an elliptic plate, fixed at the edge, under a load determined through the general $n$th-degree polynomial.

PROFESSIONAL PERSONNEL REQUISITION

## Combustion Engineer

To join a group of engineers and scientists in exploring the release of energy from various materials possessing unusual energy potential. These materials are known to hold great promise as fuels for hypersonic propulsion systems, but additional research and evaluation is necessary to make them fully productive.

Work requires extensive experience in combustion analysis and combustor designs. Position is in ASTRO, Marquardt's Air Space Travel Research Organization. You will be joining a group which is making important advances in many areas of advanced power systems.

For information, Contact:

Floyd E. Hargiss, Manager, Professional Personnel,
16553 Saticoy Street, Van Nuys, California

*Advanced power and weapons support systems for air and space*

Marquardt AIRCRAFT CO.

VAN NUYS AND POMONA, CALIFORNIA · OGDEN, UTAH

**CHALLENGING OPPORTUNITIES in RESEARCH and DEVELOPMENT for MECHANICAL DESIGN ENGINEERS**

Mechanical Engineers experienced in mechanical design for packaging electronic equipment to meet environmental conditions.

**FLUID MECHANICS ENGINEERS**

Engineers of advanced standing for work in basic and applied research in field of underwater propulsion and related subjects, including cavitation, hydroelasticity, and hydrodynamic control of submerged bodies.

Opportunities for Graduate Study

Faculty Appointments for Qualified Applicants

Excellent Working and Living Conditions

***Send Resume To:***

**ARNOLD ADDISON,**
***Personnel Director***
**The Pennsylvania State University**
**Ordnance Research Laboratory**
**P. O. Box 30**
**University Park, Pennsylvania**

When you write to manufacturers

whose advertising appears in

**Aero/Space Engineering**

it will be

of interest to the companies

and of benefit to the Institute if you

mention that you saw it in

**Aero/Space Engineering**

### *Plates with Holes*

**Kontsentratsiia Napriazhenii v Plastinke s Otverstviem.** E. F. Burmistrov. *AN SSSR Otd. Tekh. Nauk Izv.*, Aug., 1958, pp. 41–47. In Russian. Presentation of a solution, based on Muskhelishvili's method, for the plane problem of an infinite isotropic plate with an arbitrarily shaped hole. The solution of basic problems is reduced to that of a system of algebraic equations.

**Nekotorye Zadachi Teorii Izgiba Tonkikh Izotropnykh Plit s Otverstviem Obshchego Vida.** E. F. Burmistrov. *AN SSSR Otd. Tekh. Nauk Izv.*, Sept., 1958, pp. 143–147. In Russian. Study of the stress concentration in thin isotropic plates with holes subjected to bending.

### *Rings*

**Buckling of a Thin Annular Plate Uniform Compression.** N. Yamaki. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–11.*) *J. Appl. Mech.*, June, 1958, pp. 267–273. 13 refs. Solution of the problem for various combinations of the boundary conditions of the edges by integrating the equilibrium equation of the buckled plate. The lowest critical loads for each case are calculated with the ratio of its radii as the parameter. The limiting cases are discussed.

**Nonaxial Bending of Ring Plates of Varying Thickness.** H. D. Conway. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–92.*) *J. Appl. Mech.*, Sept., 1958, pp. 386–388. Presentation of a solution to the problem of bending of circular ring plates of varying thickness which are subjected at their outer and inner edges to any system of forces and moments.

**Tests of Ring-Stiffened Circular Cylinders Subjected to a Transverse Shear Load.** J. P. Peterson and R. G. Updegraff. *U.S., NACA TN 4403*, Sept., 1958. 12 pp.

**Note on the Completeness of the Elastic-Plastic Solution to Certain Boundary Value Problem for the Eccentric Ring.** Waclaw Olszak and Zenon Mróz. *Arch. Mech. Stosowanej*, No. 3, 1958, pp. 441–444.

### *Sandwich Construction*

**How to Design a Brazed Honeycomb Sandwich Structure.** F. F. Rechlin. *SAE J.*, Nov., 1958, pp. 66–69. Illustrative application of basic design suggestions for practical, producible, economical structures, and formulation of the step-by-step theoretical reasoning for arriving at a satisfactory design for a hypothetical large missile wing.

**6 Basic Design Suggestions for Brazed Honeycomb Sandwich.** F. F. Rechlin. *SAE J.*, Oct., 1958, pp. 56–63.

**Design Procedures and Data for Sandwich Panel Tests.** L. E. Kaechele. *RAND Corp. Res. Memo. RM-1963 [AD 133046]*, Aug. 13, 1957. 37 pp. Discussion of tests for determining whether the weight advantages theoretically provided by flat, simply-supported, honeycomb core sandwich panels in uniaxial compression are attainable in practice.

**Minimum-Weight Design of Sandwich Panels.** L. E. Kaechele. *RAND Corp. Res. Memo. RM-1895 [AD 133011]*, Mar. 22, 1957. 54 pp. 20 refs. Presentation of a method for determining the optimum configuration of flat, simply-supported sandwich panels under uniaxial compression. Applications to square- and hexagonal-cell honeycomb core panels are shown, and elevated temperature effects are discussed.

**Sandwich-Konstruktionen mit Wabenzellkernen im Flugzeugbau.** E. W. Pleines. *Luftfahrttechnik*, Sept. 15, 1958, pp. 230–242. In German. Discussion of the basic properties of sandwich structures with honeycomb cores for aircraft construction.

### *Testing Methods*

**A New Method to "Lock-in" Elastic Effects for Experimental Stress Analysis.** J. W. Dally, A. J. Durelli, and W. F. Riley. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–71.*) *J. Appl. Mech.*, June, 1958, pp. 189–195.

**Appareillages pour la Simulation de l'Echauffement Cinétique des Structures.** J. Gabrielli. *Docafro*, Sept., 1958, pp. 3–16. 14 refs. In French. Survey of equipment used for the simulation of kinetic heating in aircraft structures. Three conditions to be fulfilled for satisfactory simulation are stated, heat and stress quantities involved are discussed, and laboratory sources for producing and measuring these quantities are described.

**Determination of Fatigue Prone Areas in an Aircraft Wing Using a Progressive Repair Technique.** Appendix—Description of Glued Repairs. J. L. Kepert. *Australia, ARL S & M Note 246*, May, 1958. 15 pp. Discussion of a method for repairing failures in a wing to enable fatigue testing to be continued past the point of normal failure.

**Photo-Elastic Investigation of Stresses in the Heads of Thick Pressure-Vessels.** H. Fessler and R. T. Rose. *IME Proc.*, No. 20, 1957, pp. 633–643; Communications, pp. 644, 645; Authors' Reply, p. 646. 16 refs.

### Thermal Stress

**Survey of Thermal Problems as Affecting the Structures of High Speed Aircraft.** P. W. Kleeman. *Australia, ARL Rep. SM. 261,* June 1958. 50 pp. 173 refs. Discussion of problems in the following fields: aerodynamic heat transfer, heat transfer in the structure, thermal stresses, flutter, creep, fatigue, experimental methods, and materials.

**Two-Dimensional Thermal Stresses Due to Steady Heat Flow in a Semi-Infinite Aeolotropic Plate.** P. Choudhury. *J. Techn.,* June, 1958, pp. 19–24.

**O Temperaturnykh Deformatsiiakh Neodnorodnykh Obolochek.** E. L. Aksel'rad. *AN SSSR Otd. Tekh. Nauk Izv.,* Aug., 1958, pp. 48–52. In Russian. Study covering the problem of temperature deformations of nonhomogeneous shells.

**Torsion of Cylindrical and Prismatic Bars in the Presence of Steady Creep.** S. A. Patel, B. Venkatraman, and P. G. Hodge, Jr. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–27.*) *J. Appl. Mech.,* June, 1958, pp. 214–218. 11 refs. ONR-sponsored steady creep analysis. Through the elastic analog, the creep problem is reduced to one in nonlinear elasticity. The elastic analysis is carried out by means of the principles of minimum energies. Closed-form solutions for some cross sections are presented.

**Approximate Three-Dimensional Solutions of Transient Temperature Distribution in Shells of Revolution.** M. A. Brull and J. R. Vinson. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 775.*) *J. Aero/Space Sci.,* Dec., 1958, pp. 742–750.

**Coupling of Elastic and Thermal Deformations.** I. Gunadhar Paria. *Appl. Sci. Res., Sect. A,* No. 6, 1958, pp. 463–475. 17 refs. Determination of the stress and temperature distribution in a thermoelastic solid occupying the half space by using the modified form of the heat equation. As an illustration, the axial temperature distribution in a particular metal for small values of time is found.

**Prediction of Creep in Bending from Tension- and Compression-Creep Data When Creep Coefficients Are Unequal.** W. N. Findley, J. J. Poczatek, and P. N. Mathur. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–213.*) *ASME Trans.,* Aug., 1958, pp. 1,294–1,298. 13 refs.

**Inelastic Stability Theory for Creep Buckling of Plates and Shells Under Transient Loading.** J. M. Bozajian. *J. Aero/Space Sci.,* Dec., 1958, pp. 795, 796. Replacement of the short-time tangent modulus with the dynamic modulus, and generalization in the definition of the secant modulus which permits estimates of shell creep buckling under transient loads and temperatures.

**Creep Under Changing Complex Stress Systems. I, II, III.** A. E. Johnson, J. Henderson, and V. Mathur. *The Engr.,* Aug. 8; 15; 22, 1958, pp. 209–216; 251–257; 287–291. Analysis generalizing a complex stress system causing creep. Such relations have been determined for a carbon steel at 450°C., an aluminum alloy at 150°C. and 200°C., and a magnesium alloy at 20°C. and 50°C.

**Odna iz Problem Teplovogo Bar'era.** S. N. Kan. *Vestnik Vozdushnogo Flota,* July, 1958, pp. 56–61. In Russian. Investigation of thermal problems associated with high-speed flight to determine the life expectancy of supersonic aircraft. The duration of the flight is taken into account, and such factors as temperature distribution and the behavior of materials under the effect of complex loading are studied.

### Wings

**On the Stressing of Multi-Rib Thin Wings of Low Aspect Ratio and Rectangular Plan-Form.** L. S. D. Morley. *Gt. Brit., ARC R&M 3052* (Jan., 1955) 1958. 45 pp. BIS, New York, $2.88. Application of exact theories to examine the validity of certain methods of wing stressing.

## Thermodynamics

**Heat Transfer in Non-Newtonian Laminar Flow in Tubes.** J. Schenk and J. Van Laar. *Appl. Sci. Res., Sect. A,* No. 6, 1958, pp. 449–462. 27 refs. Eigenvalues and eigenfunctions are calculated for some values of the velocity profile parameter. The influence of the thermal resistance of the tube wall for radial heat flow is also investigated.

**Transport Coefficients of Air to 8000°K.** Ernest Bauer and Martin Zlotnick. *Avco RAD TR 58–12,* Sept. 29, 1958. 68 pp. 28 refs. The coefficients of viscosity, and frozen and reaction conductivity of air have been calculated for a temperature range 3,000°K. < T < 8,000°K.

**Measurements of Molecular Diffusion Coefficients.** A. A. Westenberg and R. E. Walker. (*Quart. Rev. Bumblebee Activ.,* July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274,* 1958, pp. 38–40. Presentation of a new method for measuring the molecular diffusion coefficients of gases. This method permits diffusion measurements at high temperatures and at near zero concentration.

**Calculation of the Thermal Conductivity of Porous Media.** William Woodside. *Can. J. Phys.,* July, 1958, pp. 815–823. 15 refs. Derivation of an approximate equation for the case of a cubic lattice of identical spherical particles in a medium having properties different from those of the particles.

### Combustion

**A Theory of Spray Combustion.** C. C. Miesse. *Ind. & Eng. Chem.,* Sept., Pt. I, 1958, pp. 1,303, 1,304. 13 refs. Method for determining the optimum design of a combustor with given performance requirements.

**Issledovanie Sgoraniia Gomogennoi Smesi v Turbulentnom Potoke Posredstvom Zapisi Pul'satsii Temperatury.** N. V. Kokushkin. *AN SSSR Otd. Tekh. Nauk Izv.,* Aug., 1958, pp. 3–11. In Russian. Results of an experimental investigation on the combustion of a homogeneous mixture in a turbulent stream by means of a resistance thermometer for recording temperature variations.

**Infrared Emission Spectra of Flames Under High Resolution.** E. K. Plyer and E. D. Tidwell. *J. Res.,* Oct., 1958, pp. 263–268. Investigation of the effects of adding other fuels to the oxyacetylene flame and of the changes in intensity of the emission bands when the flame is irradiated with high-frequency discharges. The region from 3.7 to 4.1 $\mu$ was measured to ascertain if bands of low intensity could be observed between the OH and $H_2O$ lines.

**Flashback and Blowoff Limits of Unpiloted Turbulent Flames.** Joseph Grumer. *Jet Propulsion,* Nov., 1958, pp. 756–759. 12 refs. Discussion of the need for further study of the stability limits of turbulent flames, and presentation of data on laminar tilted flames, as well as on turbulent flashback and blowoff limits.

**Combustion—An Aeronautical Science.** H. W. Emmons. (*IAS 1958 Minta Martin Aero. Lecture, Cambridge, Mass., Mar. 10, 1958.*) *J. Aero/Space Sci.,* Dec., 1958, pp. 730–741. 13 refs. Discussion of the basic sciences essential to an understanding of combustion and of their present limitations.

**The Concentration of Hydroxyl and of Oxygen Atoms in Gases from Lean Hydrogen-Air Flames.** W. E. Kaskan. *Comb. & Flame,* Sept., 1958, pp. 286–304. 21 refs. Measurements of OH concentrations showing that they are always in excess of equilibrium near the flame and tend to decay downstream. The effects of the addition of small amounts of nitric oxide are studied. It is shown that oxygen atoms and hydroxyl radicals are equilibrated according to the reaction $2OH \rightleftharpoons H_2O + O$.

**Hydroxyl Concentrations in Rich Hydrogen—Air Flames Held on Porous Burners.** W. E. Kaskan. *Comb. & Flame,* Sept., 1958, pp. 229–243. 18 refs. Description of a method for determining quantitatively the concentration of OH in flame gases; measurements for rich hydrogen-air flames are reported. The OH concentrations near the flame are shown to be always in excess of the calculated equilibrium concentrations.

**Emission and Absorption Studies of Hydrocarbon Combustion Products.** *Tech. News Bul.,* July, 1958, pp. 139, 140.

**Energy Distributions and Temperature Determinations in Flames.** *Tech. News Bul.,* July, 1958, pp. 131–133.

**K Teorii Tsepochechno-Teplovogo Rasprostraneniia Plameni.** L. A. Lovachev. *AN SSSR Dokl.,* June 21, 1958, pp. 1,287–1,290. In Russian. Development of the theory of thermal chain propagation of flames.

**Transition from Slow Burning to Detonation in Gaseous Explosives.** F. J. Martin. *Phys. Fluids,* Sept.-Oct., 1958, pp. 399–407. 12 refs. Description of high-speed photographic observations of flame structure, flame velocity, and shock velocity during the transition from slow burning to detonation in acetylene-oxygen mixtures contained in a Pyrex pipe at reduced pressures. Experimental procedures and results are discussed.

**Przeplywy ze Spalaniem Detonacyjnym.** Andrzej Kowalewicz. *Tech. Lotnicza,* July-Aug., 1958, pp. 94–100. In Polish. Study of gas flow with detonating burning.

**Relaksatsionnoe Vzaimodeistvie Udarnykh Voln s Zonoi Goreniia.** S. M. Kogarko and V. I. Skobelkin. *AN SSSR Dokl.,* June 21, 1958, pp. 1,280–1,283. In Russian. Investigation of the effect of combustion kinetics on the structure and strength of shock waves passing through the combustion zone.

**Measurement of Flame Speeds by a Nozzle Burner Method.** Carl Halpern. *J. Res.,* June, 1958, pp. 535–546. Navy-sponsored description of the apparatus for flame speed measurements and of the changes made to improve its performance. Values of flame speeds of methane-air mixtures obtained since 1951 are presented and compared with those obtained by two flame theories.

**O Turbulentnosti v Plameni.** A. G. Prudnikov. *AN SSSR Otd. Tekh. Nauk Izv.,* July, 1958, pp. 130–133. In Russian. Presentation of experimental results on flame turbulence by means of the optical diffusion method.

**Effect of Pressure and Duct Geometry on Bluff-Body Flame Stabilization.** A. E. Potter, Jr., and E. L. Wong. *U.S., NACA TN 4381,* Sept., 1958. 31 pp. 11 refs. Presentation of blow-off velocities and recirculation-zone lengths for propane-air flames, measured as a function of pressure, fuel-air ratio, cylinder diameter, and tunnel geometry.

### Heat Transfer

**Effects of Normal Surface Vibration on Laminar Forced Convective Heat Transfer.** J. A. Scanlan. *Ind. & Eng. Chem.,* Oct., 1958, pp. 1,565–1,568.

**Konvektivnyi Teploobmen pri Nestatsionarnom Rezhime.** E. A. Sidorov. *AN SSSR Otd. Tekh. Nauk Izv.,* Sept., 1958, pp. 116, 117. In Russian. Derivation of an approximate solution for the case of nonstationary heat convection.

**Unsteady-State Heat Transfer to and from Gases in Laminar Flow.** T. D. Patten. *IME Proc.,* No. 29, 1957, pp. 805–819; Communications, pp. 820–822. 24 refs. Presentation of an analytical expression for the prediction of outlet temperatures, assuming a varying supply inlet-temperature and nonuniform initial wall temperature.

**Diffusive Slip and Convective Diffusion of a Gas in a Capillary.** R. Ia. Kucherov. *Sov. Phys.-Tech. Phys.,* Sept., 1957, pp. 2,001–2,004. Translation. Derivation of equations which show diffusive slip to have a greater effect in capillaries when the mass difference of the diffusing gases is greater. This effect can play an important role not only in the transition region between molecular and Poiseuille flow, but also in ordinary diffusion.

**An Experimental Study of Thermal Convection in a Rotating Liquid.** R. Hide. *Royal Soc. (London) Philos. Trans., Ser. A,* July 31, 1958, pp. 441–478. 22 refs. Investigation of the hydrodynamic flow that ensues when a liquid which rotates uniformly about a vertical axis is subject to a horizontal temperature gradient.

**The Determination of Heat Transfer Surface for the Case of Zero Temperature Difference Between Cooled and Coolant Fluids at the End Point of Flow.** I. I. Gelperin and K. S. Minsker. *Sov. Phys.-Tech. Phys.,* Sept., 1957, pp. 1,987–1,992. Translation.

**On the Problem of Nonstationary Heat Transfer Through a Plate.** V. F. Glikman. *Sov. Phys.-Tech. Phys.,* Dec., 1957, pp. 2,593–2,595. Translation. Presentation of an expression for the specific thermal flux through two surfaces of the plate. Values are presented for the relative departure of the thermal flux from its stationary value.

**O Nestatsionarnoi Teplovoi Konvektsii v Sfericheskoi Polosti.** S. P. Pustovoit. *Prikl. Mat. i Mekh.,* July-Aug., 1958, pp. 568–572. In Russian. Derivation of an approximate solution for the case of weak nonstationary heat convection in a spherical cavity.

**Teplovye Volny v Sloe i Plite, Lezhashchei na Sloe.** E. I. Chernigovskaia. *AN SSSR Otd. Tekh. Nauk Izv.,* Sept., 1958, pp. 91–93. In Russian. Study of the problem covering (a) the temperature field in a layer with periodic heat sources applied to its upper surface and (b) the temperature field of a plate placed over the same layer.

**On the Free Convection from a Horizontal Plate.** Keith Stewartson. *ZAMP,* Sept. 25, 1958, pp. 276–282. Study of the boundary layer on a horizontal plate showing that, if the plate is heated and faces downward or is cooled and faces upward, a solution can be found which is in moderately good agreement with experiment.

**Local Laminar Heat Transfer in Wedge-Shaped Passages.** E. R. G. Eckert, T. F. Irvine, Jr., and J. T. Yen. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–133.*) *ASME Trans.,* Oct., 1958, pp. 1,433–1,438. USAF-supported calculation of laminar heat transfer in ducts whose cross sections have the shape of circular sectors.

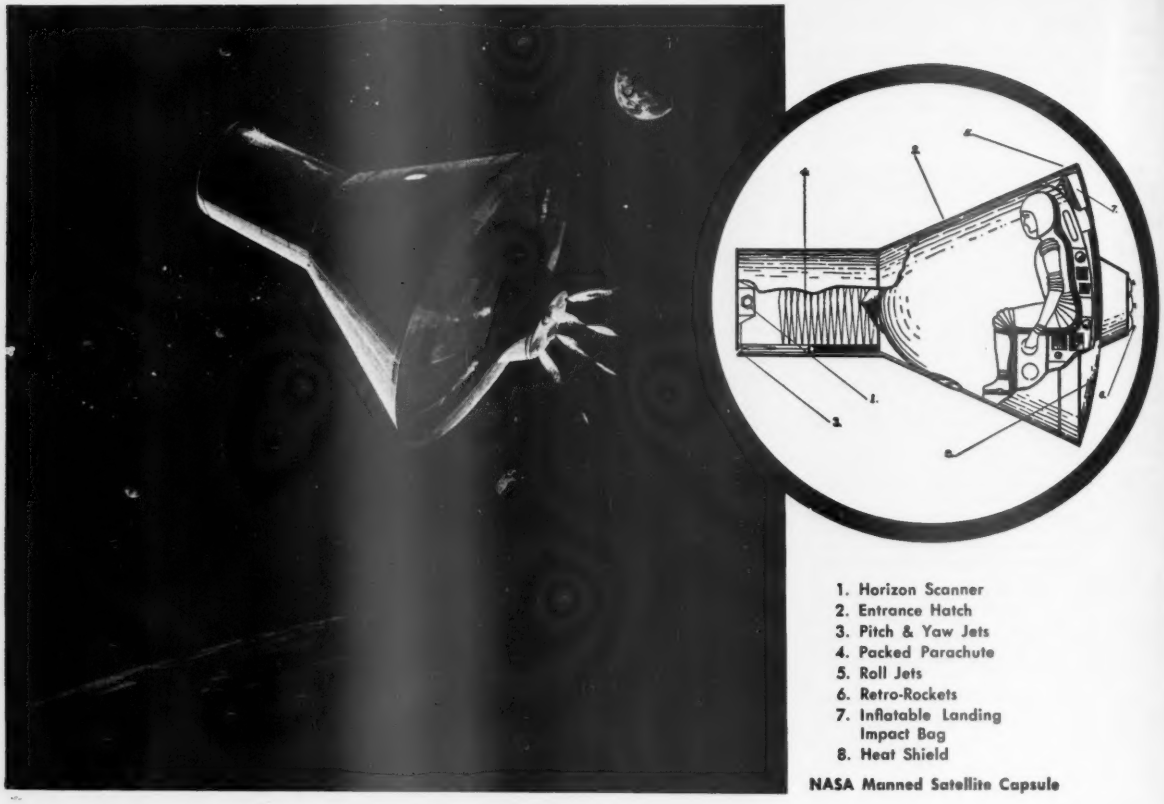
**Laminarnaia Konvektsiia nad Lineinym Istochnikom Tepla.** I. G. Sevruk. *Prikl. Mat. i Mekh.,* July-Aug., 1958, pp. 573–576. In Russian. Derivation of an asymptotic solution for the problem of laminar heat convection in the case of stationary linear heat source.

**Statistical Theory of Irreversible Processes. I—Integral Over Fluctuation Path Formulation.** David Falkoff. *Ann. Phys.,* July, 1958, pp. 325–346. 31 refs. USAF-Army-Navy-supported investigation.

**Investigation of Boiling Burnout and Flow Stability for Water Flowing in Tubes.** W. H. Lowdermilk, Ch. D. Lanzo, and B. L. Siegel. *U.S., NACA TN 4382,* Sept., 1958. 51 pp. Investigation on the forced-convection nucleate boiling process for use in cooling components of rocket motors and nuclear reactors.

**O Nestatsionarnoi Teploperedache Cherez Sistemu Diskov, Vrashchaiushchikhsia v Viazkoi Zhidkosti.** G. A. Tirskii. *AN SSSR Otd. Tekh. Nauk Izv.,* July, 1958, pp. 106, 107. In Russian. Generalization of the problem of nonstationary heat transfer for a system of discs rotating in a viscous liquid.

(*Continued on page 120*)



1. Horizon Scanner
2. Entrance Hatch
3. Pitch & Yaw Jets
4. Packed Parachute
5. Roll Jets
6. Retro-Rockets
7. Inflatable Landing Impact Bag
8. Heat Shield

**NASA Manned Satellite Capsule**

***NASA blueprint for the future***

# PROJECT MERCURY

At this moment NASA engineers and scientists are hard at work to make Project Mercury a reality. And in time a manned satellite will become reality . . . the result of outstanding professional contributions in many disciplines. This program to place man in space is typical of the projects and goals of NASA, whose responsibility it is to direct and implement U.S. research efforts in aeronautics and the exploration of space, for peaceful purposes and the benefit of all mankind.

**NASA offers unique opportunities in basic and applied research in aeronautics and space technology—**

**For Engineers:**
Aeronautical, Engineering Physics, Electronic, Mechanical, Electrical, Metallurgical, Chemical, Civil, Naval Architects.

**For Scientists:**
Astronomers, Physicists, Mathematicians, Chemists, Metallurgists.

***Please address your inquiry to the Personnel Director of any of the following NASA research centers:***

- **Langley Research Center, Hampton, Virginia**
- **Ames Research Center, Mountain View, California**
- **Lewis Research Center, Cleveland, Ohio**
- **High-Speed Flight Station, Edwards, California**
- **Beltsville Space Center, 4555 Overlook Ave., Wash., D. C.**

**(Positions are filled in accordance with Aeronautical Research Announcement 61B)**

**NASA** National Aeronautics and Space Administration

# REVIEWS OF *Books*

*. . . in the field of aeronautical engineering and space technology*

## AERONAUTICS

**Conquest of Space and Time: The Air.** Edgar B. Shieldrop. New York, Philosophical Library, 1958. 256 pp., illus., diagrs., tables. $12.

This fully illustrated story of mechanical flight forms the second of a series of four independent books on "The Conquest of Space and Time." After an account of man's earliest attempts to fly, the study of aerodynamics shows the causes of failure and reveals the basic principles of flight in heavier-than-air machines. The story of balloons and airships is not, however, forgotten, and many novel types of flying machines are described. The development of world air transport and the attainment of stratosphere travel and supersonic speeds are all covered, and the author, who is Professor of Applied Mathematics, Oslo University, and Member of the Academy of Science and of the Committee of the Society of Engineers, Norway, closes with a glimpse into the future.

## AIR TRANSPORTATION

**Alaska Flight Information Manual, Vol. 10.** U.S. Civil Aeronautics Administration, April, 1958. Washington, Superintendent of Documents, April, 1958. 48 pp., maps. $0.30.

The manual contains charts and tables of all necessary information governing flight to and within Alaska, including navigation radio aids, traffic rules. airport directory, radio communication procedures, weather broadcast schedules, emergency code, radar advisory service, and similar information essential to safe flight within the territory.

## AVIATION MEDICINE

**Aviation Medicine—Selected Reviews.** Edited by Clayton S. White, W. Randolph Lovelace, II, and Frederic G. Hirsch. (*NATO, AGARD, AGARDograph No. 25.*) New York, Pergamon Press, 1958. 305 pp., illus., diagrs., tables. $12.

*Contents:* Introduction—Paper Summaries, Clayton S. White. Spirometric Methods, Ulrich C. Luft. High-Speed Motion Picture Photography as an Aid in Bio-Medical Investigation, Merrill A. Palmer. The Measurement of Atmospheric Ozone, I. Gerald Bowen. Methods and Apparatus for the Study of Stress Reactions and Metabolic Changes, Bernard B. Longwell. Dosimetry of Ionizing Radiations, John L. Howarth. Some Technical Developments Applicable to Problems in Pathology, T. L. Chiffelle. Temperature Measuring Techniques for Aviation Physiological Research, Frederic G. Hirsch. The Analysis of Respiratory Gases, Clayton S. White. Aerosols: Physical Properties, Instrumentation and Techniques, Arnold E. Reif. Pressure Transducers—Transformer Type, James Clark. Spectrometric Methods: Gas Analysis by Quantitative Emission Spectroscopy, Clayton S. White and W. Randolph Lovelace, II. Comparison of Rahn-Otis Technique with other Methods of Intermittent and Continuous Sampling of Expired Air, Nils P. A. Lundgren. Index.

## CHEMISTRY

**Chemical Engineering Practice. Vol. 5, Fluid Systems, Part I.** Edited by Herbert W. Cremer and Trefor Davies. New York, Academic Press, Inc., 1958. 719 pp., illus., diagrs., tables. $19.50.

*Contents:* Transportation of Liquids, Walter Hey. Transportation of Gases: Fans, Blowers and Compressors, W. R. Barrett, J. Jackson, and J. Brown. Pipe Systems for Liquids and Gases, G. J. Williamson. Design of High Pressure Vessels, K. E. Bett and D. M. Newitt. Production of Vacuum, A. S. D. Barrett and B. D. Power. Liquid-Liquid Systems: Liquid-Liquid Equilibria, F. H. Garner, S. R. M. Ellis, and J. R. Bourne. Liquid-Liquid Stagewise Contact, F. H. Garner, S. R. M. Ellis, and J. G. Hughes. Extraction Equipment, D. C. Freshwater. Vapour-Liquid Equilibria, S. R. M. Ellis and M. B. Clark. Rectification of Binary Mixtures, S. R. M. Ellis and R. J. Bennett. Multicomponent Distillation, S. R. M. Ellis and P. E. Barker. Distillation Equipment, D. C. Freshwater.

**Some Problems in Chemical Kinetics and Reactivity, Vol. 1.** N. N. Semenov. Translated from the Russian by Michel Boudart. Princeton, N.J., Princeton University Press, 1958. 239 pp., diagrs., tables. $4.50.

Semenov's book on the chemical kinetics of chain reactions first appeared in 1954 as a prelude to a symposium held in Moscow by the Academy of Sciences of the U.S.S.R. The present translation derives from a new and considerably expanded edition which takes into account new data obtained from a study of the existing world literature and from research conducted at the Institute of Chemical Physics. This volume contains the first two parts of his work; the third and fourth parts on the *Kinetics of Chain Reactions* will appear in Vol. 2.

## COMPRESSORS

**Axial Flow Compressors, Fluid Mechanics and Thermodynamics.** J. H. Horlock. Toronto, Butterworth & Co. (Canada) Ltd.; London, Butterworths Scientific Publications, 1958. 189 pp., diagrs., tables. $8.00.

This book is not meant to be a complete manual for the designer of an axial compressor, but an attempt is made to present basic information to an engineer who has a training in fluid mechanics and thermodynamics up to graduate level. A short review of the required fluid mechanics and thermodynamics is given in the first chapter. The author is University Lecturer in Engineering, Cambridge University.

*Contents:* (1) Fluid Mechanics and Thermodynamics of Axial Compressors: Some Concepts. (2) Two-Dimensional Cascades: Theoretical Analyses of Performance. (3) Two-Dimensional Cascades: Experimental Work. (4) Two-Dimensional or "Pitch Line" Design of Compressor Stages. (5) Three-Dimensional Flow in Compressor Stages. (6) Calculation of Losses, Stage Efficiencies and Characteristics, and Compressor Performance Maps: Secondary Flows. (7) The Stalled Performance of Compressor Stages and the Surging of Multi-Stage Compressors. (8) Compressor Testing and Instrumentation. (9) Supersonic Compressors. *Appendix A*: Preliminary Design Study of an Axial Flow Compressor. References. Author Index. Subject Index.

## CONTROL THEORY

**Sampled-Data Control Systems.** Eliahu I. Jury. New York, John Wiley & Sons, Inc. 1958. 453 pp , diagrs., tables. $16.

This book is a source of knowledge for the treatment of industrial problems related to the basic theory of sampled-data control systems in particular, and circuits, networks, computers, and system engineering in general. Augmented with extensive examples and problems, the book describes the theory through a general approach to mixed digital-analog linear systems and a thorough discussion of the z-transform method which can be applied to a wide variety of fields. Problems arising in feedback control systems are solved and discussed by means of application of digital computers. General applications of the z-transform method and the operational solution of linear difference equations are enumerated and clarified. Special emphasis is placed on the organization, integration, and extension of material governing industrial control methods.

The author is Associate Professor of Electrical Engineering. University of California, Berkeley.

## ELECTRONICS

**Advances in Electronics and Electron Physics, Vol. 10.** Edited by L. Marton and Claire Marton. New York, Academic Press, Inc., 1958. 320 pp., illus., diagrs. $10.

*Contents:* Nonuniform D-C Electron Flow in Magnetically Focused Cylindrical Beams, William G. Dow. Defects in Diamond-Type Semiconductor Crystals, E. Billig and P. J. Holmes. Microwave Optics, John Brown. Developments in Computer Logical Organization, W. L. Lawless. On Some Aspects of Tube Reliability, E. G. Rowe. Recent Developments in the Cathode-Ray Oscilloscope, Jack E. Day. Author Index. Subject Index. Cumulative Author Index, Vols. 1–10. Cumulative Subject Index, Vols. 1–10.

**Junction Transistor Electronics.** Richard B. Hurley. New York, John Wiley & Sons, Inc., 1958. 473 pp., diagrs. $12.50.

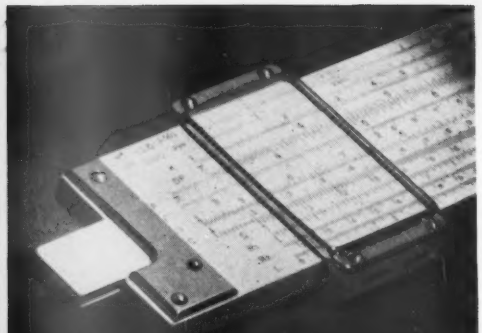
Based on lectures given in university and company electronic courses, this book emphasizes the characteristics and circuit applications of transistors. It covers applied transistor electronics, their internal physical behavior, and the important features of equivalent circuits. These major elements are introduced by use of simple, intuitive reasoning and descriptions that eliminate complex mathematical procedures. Useful tables of transistor circuit formulas and a number of numerical examples are included.

The author is Lecturer in Electrical Engineering, University of California, Berkeley.

## ENGINEERING ECONOMY

**Engineering Economy.** Clarence E. Bullinger. 3rd Ed. New York, McGraw-Hill Book Company, Inc., 1958. 379 pp., diagrs., tables. $7.00.

Appearing last in 1950 as *Engineering Economic Analysis*, this work provides an understanding of the type of economic study which engineers in industry have to make when considering the functional solution of engineering problems. In the current edition all cost data have been brought up to date; a new discussion of decision making has been added and new operations research procedures have been introduced, particularly the concept of the development of "models" and "criteria." Using the simple "profit-and-loss" statement in business as a model, the author shows how other traditional



# Scope and adventure in RCA BMEWS engineering positions

On the Ballistic Missile Early Warning System, you work with equipments which are largest in their fields . . . the most complex project in military electronics . . . exploring interesting areas of scientific unknowns.

*Immediate openings include positions for:*

**PROJECT ENGINEERS**—assume systems responsibility during installation, checkout and integration and provide engineering leadership thereafter. EE, plus advanced theoretical knowledge.

**DESIGN ENGINEERS**—association with equipments through initial design and responsibility for checkout, integration and redesign. EE or ME, circuit design and field experience desirable.

Work at desirable New Jersey locations . . . or on field assignments (temporary or permanent) in Alaska and other areas. Excellent salaries, plus added compensation for field assignment. Unusual opportunities for rapid advancement. Complete RCA benefit program for you and your family.

For details, act today!

**Mr. Robert Vincent**
**RCA, Dept. BM-6B**
**1809 Bannard St., Riverton, N. J.**

EQUAL JOB OPPORTUNITY For All Qualified Applicants

**Have _____ Project Engineer _____ Design Engineer experience you need on BMEWS.**

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

RCA

**RCA SERVICE COMPANY**
**A DIVISION OF RADIO CORPORATION OF AMERICA**

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

models in engineering economy have been derived and makes some indication of their relative advantages and disadvantages. The effect of federal and state income taxes on engineering projects is a new inclusion, and the many illustrative materials and problems have all been revised.

## LAWS AND REGULATIONS

**Civil Air Regulations and Flight Standards for Pilots.** Associated Aeronautical Staff of Aero Publishers. 20th Ed. Los Angeles, Aero Publishers, Inc., 1958. 160 pp., diagrs. $2.25.

**Civil Air Regulations and Reference for Mechanics.** Associated Aeronautical Staff of Aero Publishers. 14th Ed. Los Angeles, Aero Publishers, Inc., 1958. 152 pp., diagrs. $2.50.

## MATERIALS

**The Metal Thorium; Proceedings of the Conference on Thorium, Held October 11, 1956 at Cleveland, Ohio, Under the Joint Sponsorship of U.S. Atomic Energy Commission, and American Society for Metals.** Harley A. Wilhelm, Technical Editor. Cleveland, Ohio, American Society for Metals, 1958. 397 pp., illus., diagrs., tables. $10.

*Contents:* (1) The Role of Thorium Metal in the Nuclear Field, John P. Howe. (2) The Nonnuclear Application of Thorium, W. C. Lilliendahl. (3) Thorium in Magnesium Technology, T. E. Leontis. (4) Production of Thorium Compounds, J. J. Barghusen and M. Smutz. (5) Preparation of Thorium Oxide and Thorium Fluoride From Thorium Nitrate, Ray W. Fisher. (6) Development of the Thorium Tetrafluoride-Calcium Process for Thorium Metal, H. A. Wilhelm. (7) Preparation of Iodide Thorium, N. D. Veigel, E. M. Sherwood, and I. E. Campbell. (8) Consumable-Electrode Arc Melting of Thorium, A. H. Roberson and Robert A. Beall. (9) Electrolytic Refining of Thorium, Robert A. Noland. (10) Physical Constants, Crystal Structure, and Thermodynamic Properties, J. F. Smith. (11) Electronic Structure of Thorium Metal, Ted G. Berlincourt. (12) Preferred Orientation in Thorium, L. K. Jetter and C. J. McHargue. (13) Mechanical Properties of Thorium and High-Thorium Metals, J. A. Milko, R. E. Adams, and W. O. Harms. (14) Recrystallization of Thorium, E. J. Boyle (15) Fabrication and Cladding of Thorium Metal, J. E. Cunningham. (16) The Corrosion of Thorium and Its Alloys, W. E. Berry, R. S. Peoples, and H. A. Pray. (17) Effects of Irradiation Upon Thorium, Frank G. Foote and J. Howard Kittel. (18) Metallography of Thorium, H. P. Roth. (19) Hazards Associated with Thorium Metallurgy, A. F. Voigt. (20) The Constitution of Thorium Alloys, F. A. Rough, Arthur A. Bauer, and H. A. Saller. (21) Chemical Analysis of Thorium Metal, C. J. Rodden and M. W. Lerner. (22) The Spectrographic Analysis of Thorium, Velmer A. Fassel and Edward DeKalb.

**Powder Metallurgy in Nuclear Engineering; Proceedings of the Conference on Powder Metallurgy in Atomic Energy, Held October 20, 1955 in Philadelphia Under Joint Sponsorship by U.S. Atomic Energy Commission and American Society for Metals.** Organized by Henry H. Hausner. Cleveland, Ohio, American Society for Metals, 1958. 275 pp., illus., diagrs., tables. $8.50.

*Contents:* (1) General Metallurgical Problems in the Design of Nuclear Reactors, Vincent P. Calkins. (2) Factors Affecting Sintering, L. L. Seigle and A. L. Pranatis. (3) Preparation of Metal Powders for Reactors, P. Chiotti and H. A. Wilhelm. (4) Powder Metallurgy of Zirconium and Beryllium, Harold H. Hirsch. (5) Powder Metallurgy of Uranium, Henry H. Hausner and John L. Zambrow. (6) Powder Metallurgy of Thorium, W. W. Beaver and K. G. Wikle. (7) Alloying by Powder Metallurgy, H. A. Saller and F. A. Rough. (8) Uranium Alloys by Powder Metallurgy, Herbert S. Kalish. (9) Zirconium-Beryllium Phase Diagrams, Henry



XUM

H. Hausner and Herbert S. Kalish. (10) New Methods of Powder Metallurgy, W. D. Manly and J. H. Coobs. (11) Metal-Powder Rolling, Samuel Storchheim. (12) Ceramic Fuel Materials for Nuclear Reactors, J. R. Johnson. (13) Uranium Dioxide as a Nuclear Fuel Material, Henry H. Hausner and R. G. Mills. (14) Dispersion-Type Fuel Elements, C. E. Weber and H. H. Hirsch. (15) Safe Handling of Pyrophoric and Radioactive Metal Powders, W. B. Harris.

**Epoxy Resins.** Irving Skeist and George R. Somerville. (Reinhold Plastics Applications Series.) New York, Reinhold Publishing Corporation, 1958. 293 pp., illus., diagrs., tables. $5.50.

Except for some of the background chapters, this book is addressed to the reader without extensive chemical training and provides a comprehensive description of the users of the new epoxies as casting and potting compounds, adhesives, and plasticizers. It also clarifies the puzzling array of trade names, and presents up-to-date formulations and manufacturing procedures.

**Gum Plastics.** M. Stafford Thompson. (Reinhold Plastics Applications Series.) New York, Reinhold Publishing Corporation, 1958. 193 pp., illus., diagrs., tables. $4.50.

This treatment of rubber-modified plastic resins and their uses emphasizes the applications of impact-polystyrene, ABS polymers, and impact PVC, and covers the general properties, chemistry, and fabrication of these compounds. Special attention has been given to new applications, new compounds, and a discussion of applications now in the developmental stage.

## MATHEMATICS

**Mathematical Tables and Formulae.** F. J. Camm. New York, Philosophical Library, 1958. 144 pp., tables. $2.75.

This compendium brings together, for easy reference, the most frequently consulted arithmetical, trigonometrical, and algebraic tables and formulas. Included are the standard mathematical symbols, simple and compound interest tables, weights and measures, mathematical and geometrical progressions, conversion tables, laws of physics, formulas in algebra and calculus, and other formulas that generally are scattered throughout textbooks dealing with the various branches of mathematics.

**Ordinary Differential Equations.** Wilfred Kaplan. Reading, Mass., Addison-Wesley Publishing Company, Inc., 1958. 534 pp., diagrs. $8.50.

Intended as a text for a first course in differential equations, the distinguishing feature of this work is its use of the new ideas of instrumentation engineering, both as an illustration of the theory and as a way of better understanding the mathematics. While it covers the topics usually included in an introductory course, it gives special emphasis to gaining a deeper understanding of the subject, rather than to learning special devices. To this end, the differential equations are related to their applications in physics and engineering, especially with regard to those aspects which are important for servomechanisms, computers, and automatic control. Consequently, the book is especially suited for use by those going on in the field of instrumentation and control.

The author is associated with the Department of Mathematics, University of Michigan.

**An Introduction to Fourier Methods and the Laplace Transformation.** Philip Franklin. (Reprint of the 1949 Edition entitled: *Fourier Methods.*) New York, Dover Publications, Inc., 1958. 289 pp., diagrs. $1.75.

**Introduction to Bessel Functions.** Frank Bowman. (Reprint of 1938 Edition.) New York, Dover Publications, Inc., 1958. 135 pp. $1.35.

**Vector Analysis with an Introduction to Tensor Analysis.** A. P. Wills. (Reprint of 1931


*NOW IN ITS SECOND YEAR*

# THE PHYSICS OF FLUIDS

***Original contributions to the physics of fluids covering kinetic theory, statistical mechanics, structure and general physics of gases, liquids, and other fluids and including:***

- Magneto-Fluid Dynamics
- Ionized Fluid and Plasma Physics
- Shock and Detonation Wave Phenomena
- Dynamics of Compressible Fluids
- Boundary Layer and Turbulence Phenomena
- Liquid State Physics and Superfluidity
- Hypersonic Physics
- Rarefied Gas Phenomena
- Upper Atmosphere Phenomena
- Physical Aeronomy
- Transport Phenomena
- Hydrodynamics

***As well as certain basic aspects of physics of fluids bordering geophysics, astrophysics, biophysics and other fields of science. Published by the American Institute of Physics and edited by a distinguished board of scientists, the publication will be indispensable to all research workers, libraries, laboratories, and institutions interested in the broad field of the physics of fluids.***

**Editor, F. N. Frenkiel, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.**

**Issued bimonthly—**
**Sub. Rates: $10.00 domestic, $11.00 foreign**

***Orders and Inquiries should be addressed to:***

**AMERICAN INSTITUTE OF PHYSICS**
**335 East 45 Street** **New York 17, N. Y.**



**ATTENTION ADVERTISERS**

**YOUR BEST INVESTMENT**

**IN**

**ENGINEERING READERSHIP**

**IS**

# AERO/SPACE ENGINEERING

The ONLY magazine serving the technical interests of professional engineers and design project teams currently developing Missiles, Rockets, Aircraft, Satellites, and Spacecraft.

Edition.) New York, Dover Publications, Inc., 1958. 285 pp. $1.75.

### MECHANICS

**Theoretical Mechanics: Statics and the Dynamics of a Particle.** William Duncan MacMillan. (Reprint of 1927 Edition.) New York, Dover Publications, Inc., 1958. 430 pp., diagrs. $2.00.

**Theoretical Mechanics, An Introduction to Mathematical Physics.** Joseph Sweetman Ames and Francis D. Murnaghan. (Reprint of 1929 Edition.) New York, Dover Publications, Inc. 462 pp., diagrs. $2.00.

### METEOROLOGY

**Polar Atmosphere Symposium, Symposium at Oslo, July 2–8, 1956. Part 1, Meteorology Section,** Edited by R. C. Sutcliffe; **Part 2, Ionospheric Section,** Edited by K. Weekes. (*NATO, AGARD, AGARDograph No. 29, Parts 1 and 2.*) London; New York, Pergamon Press, 1957-1958. **Pt. 1,** 341 pp., illus., diagrs., tables. $12.; **Pt. 2,** 212 pp., illus., diagrs., tables. $10.50.

### MISSILES

**Missile Engineering Handbook.** C. W. Besserer. (*Principles of Guided Missile Design*; Edited by Grayson Merrill.) Princeton, N.J., D. Van Nostrand Company, Inc., 1958. 600 pp., diagrs., tables. $14.50.

This collection of equations, formulas, graphs, and tables has been selected and arranged to aid practitioners of missilery and space flight in developing preliminary designs and parametric studies important in weapon system analysis. Also supplied is an extensive glossary of guided missile and space flight terms. The *Handbook* will be particularly helpful to those whose "need-to-know" does not entitle access to classified data. The data are generally self-explanatory but, in some cases, are presented without instructions for application or qualifications as to tolerances or other limitations. Although suitable for preliminary design, comparative analysis, and problem solution by students, they should be checked against data supplied by manufacturers in an actual design case. The reader is presumed to have a knowledge of guided missile practice equivalent to that given in other volumes of the parent series, "Principles of Guided Missile Design."

The author is on the Senior Technical Staff, Space Technology Laboratories, The Ramo-Wooldridge Corporation.

### PHYSICS

**Solid State Physics; Advances in Research and Applications, Vol. 7.** Edited by Frederick Seitz and David Turnbull. New York, Academic Press, Inc., 1958. 525 pp., illus., diagrs., tables. $12.

The introduction contains a listing of the contents of the previous six volumes, and a bibliography of articles that will appear in future volumes.

*Contents*: Thermal Conductivity and Lattice Vibrational Modes, P. G. Klemens. Electron Energy Bands in Solids, Joseph Callaway. The Elastic Constants of Crystals, H. B. Huntington. Wave Packets and Transport of Electrons in Metals, H. W. Lewis. Study of Surfaces by Using New Tools, J. A. Becker. The Structures of Crystals, A. F. Wells.

**The Fundamental Principles of Quantum Mechanics with Elementary Applications.** Edwin C. Kemble. (Reprint of 1937 Edition.) New York, Dover Publications, Inc., 1958. 611 pp., diagrs. $2.95.

### RESEARCH

**A Selected Bibliography of Research and Development and Its Impact on the Economy.** (*NSF-58-18.*) Washington, Office of Special Studies, National Science Foundation, May, 1958. 21 pp.

Scientific research and its impact on our economy have rapidly become of intense public interest and concern, and the pertinent literature has grown in proportion. This bibliography is an initial effort to meet the need for a compilation of the references to this literature, and, taken in its entirety, it represents a suggestive rather than an exhaustive review. Terminology and concepts in this field have been in a state of flux, so that a major problem was to seek out the labels under which related topics were categorized. In the 20-year period from 1938 to 1958, emphasis and concern have shifted, for example, from questions of economic stability and patent monopoly to problems of economic growth and the impact of research and development. Bibliographic references, for the most part, pertain to the American economy, with a special section devoted to industrial research. Specialized aspects of technology and research, such as automation and atomic energy, are treated only in so far as a benchmark for gauging the selection of a broad range of ideas and issues.

### SAFETY

**Aviation Safety Officers Guide.** U.S. Naval Aviation Safety Center. Norfolk, Va., 1957. 69 pp., illus.

This guide is designed primarily to assist the Squadron Aviation Safety Officer in implementing and prosecuting an active aircraft accident prevention program. Suggestions are given for the organization of a safety department, monthly safety themes, aero-medical and maintenance safety, a preaccident plan, and incentives, contests, and awards connected with safety.

**Ejection Seat Study; A Report of Ejections and Bailouts for Calendar Year 1957.** U.S. Naval Aviation Safety Center. Norfolk, Va., 1958. 26 pp., diagrs., tables.

The purpose of this study is to present an analysis of the emergency uses of the ejection seat for the period covered; to appraise operating commands of the ejection seat record; and to present brief discussions concerning the factors which influence the success of the ejection procedure.

### UPPER ATMOSPHERE RESEARCH

**Manual on Rockets and Satellites.** Edited by L. V. Berkner; Associate Editors: Gilman Reid, John Hanessian, Jr., and Leonard Cormier. (Annals of the International Geophysical Year, Vol. 6.) London; New York, Pergamon Press, 1958. 508 pp., illus., diagrs., tables. $25.

This Manual consists of a series of scientific papers derived from what the editor believes to be "the best of the scientific literature so far available" in the fields of rocketry and earth satellite exploration. The special section on the IGY rocket program covers the program as it is being carried out in the following countries: Australia, Canada, France, Japan, the U.S.S.R., the United Kingdom, and the United States. The section on the IGY earth satellite program covers general satellite information, the U.S.S.R. satellite program, the United States satellite program, and other countries participating in IGY earth satellite research. Also presented are CSAGI Conference Resolutions and a CSAGI Guide to World Data Centers. Many papers are presented in almost their complete original form. An effort has been made to select papers covering all of the important aspects of the subject within the range of our present knowledge, thus providing a guide for those who will carry on observations in the field or who will use the observations obtained by these methods for subsequent theoretical or experimental activities. Therefore, so far as possible, all aspects of the IGY program of rockets and satellites have been included.

The editor is President, International Council of Scientific Unions, and CSAGI Reporter for Rockets and Satellites.

✦ ✦ ✦

## Reviews (*Continued from page 115*)

**Finite Difference Method for Calculating Transient Temperature Distributions Due to One Dimensional Heat Flow in Simple and Composite Bodies.** Herbert Schuh. (*VDI Forschungsheft 459*, 1957.) *Gt. Brit., RAE, Lib. Transl. 750*, July, 1958. 78 pp. 20 refs.

**Kraevaia Zadacha v Teorii Teplovogo Vzryva.** V. V. Barzykin and G. G. Merzhanov. *AN SSSR Dokl.*, June 21, 1958, pp. 1,271–1,273. In Russian. Investigation of the boundary problem in the theory of thermal explosions.

**O Nestatsionarnoi Teplovoi Konvektsiiv Sharovom Sloe.** I. G. Sevruk. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 419–423. In Russian. Derivation of an approximate solution for the problem of nonstationary heat convection in a liquid bounded by two concentric spherical surfaces at constant temperature.

**Blowdown and Charging Processes in a Single Gas Receiver with Heat Transfer.** W. C. Reynolds and W. M. Kays. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A-137.*) *ASME Trans.*, July, 1958, pp. 1,160–1,168. Analysis of the general problem of blowdown and charging. An experimental investigation of blowdown through a critical flow nozzle with heat transfer is described; the results yielded are in good agreement with the analysis.

## VTOL & STOL

**The Place of VTOL and STOL Aircraft in Civil Transport.** F. H. Robertson. *Aeronautics*, Sept., 1958, pp. 185–196 (ff.).

**The Self-Sufficient Vehicle.** D. M. Desoutter. *Aeronautics*, Aug., 1958, pp. 24–31. Discussion on the importance of Rotodyne in the transport field. Its performance is indicated and its structural and mechanical systems are examined.

**Fundamentals of Annular Airfoil Theory (Nozzles in a Free Stream).** H. E. Dickmann. (*Ing.-Arch.*, vol. 11, 1940.) *Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech. PIBAL Rep. 353*, Aug., 1956. 36 pp. Analysis of the interaction of flow fields produced by singularities which simulate component parts of a ducted propeller.

**Vertical Take-Off Aircraft: Some Design Problems.** David Keith-Lucas. *Shorts Quart. Rev.*, Sept., 1958, pp. 2–8. (Also abridged in *Shell Av. News*, July, 1958, pp. 11–13.) Discussion on the problem of building an aircraft with VTOL capabilities; the contribution made by the SC.1 research aircraft is described.

**Tilt-Wing VTOL.** J. P. Kushnerick. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 36–39. Description of the control and propulsion systems of the Vertol 76, which combines the helicopter and fixed wing concepts.

**The Fairey Rotodyne; Centre-to-Centre Airliner.** J. H. Stevens. *Aircraft* (Canada), Aug., 1958, pp. 20, 21, 23–26, 68–70 (ff.).

**Preliminary Investigation of a Ducted Fan in Lifting Flight.** N. D. Ham and H. H. Moser. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 827.*) *AHS J.*, July, 1958, pp. 17–29. 16 refs.

**Breguet "940" Blown-Wing Aircraft.** *The Engr.*, Aug. 29, 1958, pp. 351, 352. Design details of a French STOL aircraft.

## Water-Based Aircraft

**Water-Impact Theory for Aircraft Equipped with Nontrimming Hydro-Skis Mounted on Shock Struts.** Emanuel Schnitzer. *U.S., NACA TN 4256*, Sept., 1958. 29 pp.

# IAS CORPORATE MEMBERS

AC Spark Plug Division, General Motors Corporation

Academy of Aeronautics

Adams Rite Manufacturing Company

Aerojet-General Corporation

Aerolab Development Company

Aeronca Manufacturing Corporation

Aeronutronic Systems, Inc.

Aeroquip Corporation

Agawam Aircraft Products, Inc.

Allied Research Associates, Inc.

Allis-Chalmers Manufacturing Company

Allison Division, General Motors Corporation

Aluminum Company of America

American Airlines, Inc.

American Bosch Arma Corporation

American Non-Gran Bronze Company

American Steel & Wire Division, United States Steel Corporation

Amoco Chemicals Corporation

Amphenol Electronics Corporation

Anderson, Greenwood & Co.

Arde Associates

Associated Aviation Underwriters

Avco Research Laboratory

Avien, Inc.

Avro Aircraft Limited

Baker Steel & Tube Company

Beech Aircraft Corporation

Bell Aircraft Corporation

Bendix Aviation Corporation

The BG Corporation

Boeing Airplane Company

Booz, Allen & Hamilton

The Bristol Aeroplane Company (U.S.A.) Inc.

Bulova Research and Development Laboratories, Inc.

Canadair, Ltd.

The Cessna Aircraft Company

Chance Vought Aircraft, Incorporated

The Chase Manhattan Bank

Chicago Aerial Industries, Inc.

The Cleveland Pneumatic Industries, Inc.

Consolidated Controls Corporation

Continental Motors Corporation

Cornell Aeronautical Laboratory, Inc.

Curtiss-Wright Corporation

The Decker Corporation

Del Mar Engineering Laboratories

Delco-Remy Division, General Motors Corporation

Doak Aircraft Company, Inc.

Douglas Aircraft Company, Inc.

Dzus Fastener Company, Inc.

Eastern Air Lines, Inc.

Edo Corporation

Elastic Stop Nut Corporation of America

Electrol Incorporated

Engineering Supervision Company

Esso Standard Oil Company

Fairchild Camera and Instrument Corporation

Fairchild Engine and Airplane Corporation

The Firestone Tire & Rubber Company

The Garrett Corporation

General Dynamics Corporation

General Electric Company

General Precision Equipment Corporation

G. M. Giannini & Co., Inc.

Giannini Plasmadyne Corporation

The B. F. Goodrich Company

Goodyear Aircraft Corporation

Grumman Aircraft Engineering Corporation

Hydro-Aire, Inc.

Insurance Company of North America Companies

International Business Machines Corporation

The International Nickel Company, Inc.

ITT Laboratories, Division of International Telephone and Telegraph Corporation

Janitrol Aircraft Division, Surface Combustion Corporation

Johns-Manville Sales Corporation

Earle M. Jorgensen Co.

Kelsey-Hayes Company

Walter Kidde & Company, Inc.

Kollsman Instrument Corporation

Koppers Company, Inc.
Sound Control Department

Lavelle Aircraft Corporation

Lear, Incorporated

C. W. Lemmerman, Inc.

Librascope, Incorporated

The Liquidometer Corporation

Lockheed Aircraft Corporation

Loewy-Hydropress Division of Baldwin-Lima-Hamilton Corporation

Longines-Wittnauer Watch Company, Inc.

Marquardt Aircraft Company

The Martin Company

Martin Steel Products Corporation

McDonnell Aircraft Corporation

Meletron Corporation

Mid-Continent Manufacturing, Inc.

Minneapolis-Honeywell Regulator Company

National Credit Office, Inc.

North American Aviation, Inc.

Northrop Aircraft, Inc.

Nuclear Development Corporation of America

Pan American World Airways, Inc.

The Ralph M. Parsons Company

Pesco Products Division, Borg-Warner Corporation

Phillips Petroleum Company

Piasecki Aircraft Corporation

Radio Corporation of America, Defense Electronic Products

Republic Aviation Corporation

Rohr Aircraft Corporation

Paul Rosenberg Associates

Ryan Aeronautical Company

Sandberg-Serrell Corporation

Shafer Bearing Division, Chain Belt Company

Shell Oil Company

Simmonds Aerocessories, Inc.

Socony Mobil Oil Company, Inc.

Solar Aircraft Company

Southwest Products Co.

R. Dixon Speas Associates

Sperry Gyroscope Company Division of Sperry Rand Corporation

Standard Oil Company of California

Standard Oil Company (Indiana)

Standard-Thomson Corporation
Clifford Manufacturing Division

Stanley Aviation Corporation

Thiokol Chemical Corporation

Thompson Ramo Wooldridge Inc.

Trans World Airlines, Inc.

Turbo Products, Inc.

Union Carbide Corporation

United Air Lines, Inc.

United Aircraft Corporation

United States Aviation Underwriters, Inc.

Vard, Inc.

Vertol Aircraft Corporation

Vitro Corporation of America

Western Gear Corporation

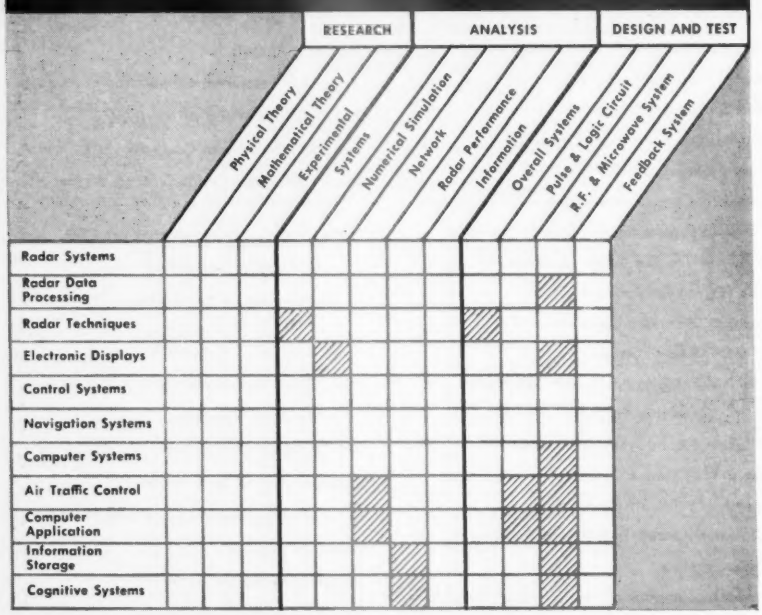
Westinghouse Electric Corporation

Weston Instruments Division of Daystrom, Inc.

Wyman-Gordon Company

Young Radiator Company

# WHAT SQUARES CAN YOU FILL IN THIS R & D MATRIX?




## YOUR OPPORTUNITY IN ELECTRONICS AT CORNELL AERONAUTICAL LABORATORY

The ever expanding breadth of C.A.L.'s research program staffed by 400 engineers and scientists opens outstanding opportunities for capable, imaginative, electronics men. Whether a systems engineer or a specialist, you will find our unique combination of academic and industrial research atmosphere refreshing and rewarding. You will find welcome freedom from production-line pressures that hinder creative accomplishment. We invite you to match your skills and interests against our needs.

**CORNELL AERONAUTICAL LABORATORY, INC. of Cornell University**

**WRITE FOR FREE REPORT**

The story behind Cornell Aeronautical Laboratory and its contributions to aeronautical progress is told in a 68-page report, "A Decade of Research." Whether you are interested in C.A.L. as a place to work or as a place to watch, you will find "A Decade of Research" both useful and pertinent. Mail the coupon now for your free copy.

J. A. Ruch EM
**CORNELL AERONAUTICAL LABORATORY, INC.**
Buffalo 21, New York

Please send me "A Decade of Research."

Name _____

Street _____

City _____ Zone _____ State _____

☐ Please include employment information.

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

# AERO DYNAMICIST

*to provide project leadership in the planning of radically new space vehicle concepts at Missile & Space Vehicle Department of General Electric*

Programs concerned with salient areas of missile and space technology require an imaginative and experienced aerodynamicist who can visualize beyond the parameters imposed by today's state of the art.

Immediate openings exist for engineers to plan and implement free flight and drop test aerodynamic experiments for the purpose of obtaining data pertinent to development of advanced weapons systems and space vehicles. Must have technical competence to develop new methods of obtaining data and the ability to conduct theoretical and experimental analyses of specific experimental systems which will lead to the determination of overall design requirements.

Please submit your qualifications in complete confidence to:

Mr. R. L. Eddy, Dept. 700-3
Professional Placement

**GENERAL ELECTRIC**

**Missile and Space Vehicle Department**

3198 Chestnut St.
Philadelphia 4, Pa.

# ENGINEERS
AND
# SCIENTISTS

Here is your opportunity to grow with a young, expanding subsidiary of the Ford Motor Company. Outstanding career opportunities are open in Aeronutronic's new RESEARCH CENTER, overlooking the Pacific at Newport Beach, and the facility in Glendale, California. You will have all the advantages of a stimulating mental environment, working with advanced equipment in a new facility, located where you can enjoy California living at its finest.

**PhD and MS RESEARCH SPECIALISTS** with 5 to 7 years' experience in heat transfer, fluid mechanics, thermodynamics, combustion and chemical kinetics, and thermoelasticity. To work on theoretical and experimental programs related to re-entry technology and advanced rocket propulsion. Specific assignments are open in re-entry body design, high temperature materials studies, boundary layer heat transfer with chemical reaction, thermal stress analysis, and high temperature thermodynamics.

**PROPULSION ENGINEERS** with 5 years' experience in liquid and solid rocket design and test. Familiarity with heat transfer problems in engines desirable. To work on program of wide scope in R & D of advanced concepts in rocket engine components, and for missile project work.

**ADVANCED AERODYNAMIC FACILITY DESIGNER.** Advanced degree desired. To supervise work in design and in instrumentation of advanced aerodynamic test facilities such as shock tubes, shock tunnels, plasma-jets, and hyper-velocity guns.

**STRUCTURAL ANALYSIS SECTION SUPERVISOR** with 8 to 10 years' experience, including supervision, in the missile field. Graduate degree for design and analysis required. Will be required to apply knowledge of high temperature materials and methods, thermal stress, dynamics, etc., to advanced hypersonic vehicles re-entry bodies, and space vehicles.

**FLIGHT TEST & INSTRUMENTATION ENGINEERS** with 5 to 10 years' experience in laboratory and flight test instrumentation techniques. Will develop techniques utilizing advanced instrumentation associated with space vehicles.

**THEORETICAL AERODYNAMICIST.** Advanced degree and at least 5 years' experience in high-speed aerodynamics. Knowledge of viscid and inviscid gas flows required. To work on program leading to advanced missile configurations. Work involves analysis of the re-entry of hypersonic missiles and space craft for determining optimum configuration.

**DYNAMICIST.** Advanced degree, applied mathematics background, and experience in missile stability analysis desirable. Work involves re-entry dynamics of advanced vehicles and dynamic analysis of space craft.

**ENGINEER or PHYSICIST.** With experience in the use of scientific instruments for making physical measurement. Work related to flight test and facility instrumentation. Advanced degree desired with minimum of 3 years of related experience.

Qualified applicants are invited to send resumes and inquiries to Mr. K. A. Dunn, Aeronutronic Systems, Inc.

## AERONUTRONIC
a subsidiary of Ford Motor Company

1234 Air Way Bldg. 13, Glendale, Calif.
CHapman 5-6651

Newport Beach, Glendale, Santa Ana, and Maywood, California


# *Personnel Opportunities*

*This section is for the use of individual members of the Institute seeking new connections and eligible organizations offering employment to specialists in the aero/space industry. Any member or eligible organization may have requirements listed without charge by writing to the Secretary of the Institute.*

## Wanted

**Aerodynamicists**—with theoretical and practical knowledge in supersonics and hypersonics. Salaries range from $5,000 to $30,000. There are two high-level positions immediately available, in addition to several junior and intermediate openings. These lucrative positions require creative thinkers with experience in one or more of the following: aerodynamic design; stability and control; aerodynamic heating; flutter, static and dynamic aeroelasticity; performance; aerodynamic testing; flight control systems; gasdynamics or internal aerodynamics. For immediate consideration send a detailed résumé to E. Greenlee, Personnel Manager, Arde Engineering Division, 75 Austin St., Newark 2, N.J.

**Aeronautical Design Evaluation Engineers**—CAA needs experienced aeronautical engineers in aircraft structures and power-plant installations. Aeronautical design evaluation engineers (structures) will be responsible for structural evaluation of commercial aircraft and aircraft component designs in determining compliance with Civil Air Regulations, with particular reference to helicopters and turbine-powered transports. Aeronautical power-plant design evaluation engineers will be responsible for the evaluation of similar aircraft with specific reference to power-plant installations, including turbine engines and their related systems. Salaries range from $6,285 to $8,810 annually. Those interested should submit résumé or contact Personnel Division, Federal Building, Civil Aeronautics Administration, New York International Airport, Jamaica 30, N.Y. Telephone: OLympia 9-7000, ext. 354.

**Electronic Scientists, Metallurgists, Physicists, Technologists, and Engineers** (Aeronautical, Electrical, Electronic, Industrial, General, Mechanical, and Power Plant)—The Naval Air Material Center, Philadelphia 12, Pa., has an urgent need for qualified engineering and scientific personnel to fill vacancies in the above positions. The Center is currently engaged in an extensive program of aeronautical research, development, experimentation, and test operations for the advancement of Naval aviation. Experimental work is also being conducted in the guided-missile field. Starting salaries range from $4,490 to $8,330 per annum. Application for Federal Employment, Standard Form 57, should be filed with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the above address, or information as to where they are available may be obtained from any first- or second-class post office.

**Associate Professorship**—8810, Mathematics Department of Air Force Institute of Technology, Dayton, Ohio. Most of the work is at advanced undergraduate and graduate level. One quarter out of four free of teaching duties for research or other academic pursuits, plus vacation. Working conditions comparable to those in leading universities. If interested, contact Dr. Albert B. Carson, Head, Mathematics Department, AF Institute of Technology, Wright-Patterson AFB, Ohio.

**Engineers**—Electronic Engineers, Physicists, Aerodynamicists, and Mathematicians. Fairchild Astrionics Division, Fairchild Engine & Airplane Corp., Wyandanch, Long Island, N.Y. Numerable positions now available in our research, design, and development departments. Specific assignments for experienced personnel in groups responsible for the design and development of systems—subsystems and components for missiles, airborne and ground electronics, training devices and weapons systems. Apply in confidence to William R. Ziminski, Personnel Manager.

**The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.**

## Available

**898. Field Service Engineering Director**—Registered Professional M.E., thoroughly experienced in field-service engineering. Commander, USNR; Naval Aviator, current flight status; former NAS C.O. Carrier experience. Last 8 years, research and consulting with prominent nationally known organization. Long record of accomplishment with clients. Customer relations, product application, and administering of field-service personnel. Thoroughly seasoned traveler. East coast preferred; however, will relocate provided challenge and opportunities warrant. Broad experience in training and developing all levels of personnel. Qualified CAA commercial pilot with instrument rating, for all single-, multiengine land and seaplanes. Years of maintenance experience, current CAA A&E ticket. Detailed résumé forwarded upon request.

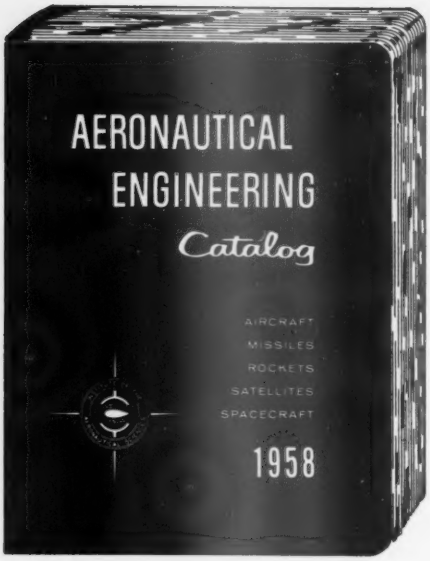
**897. Engineer**—M.E., M.S.; 12 years' experience in research and development of electromechanical systems, including inertial systems and devices, servo and computer systems, autopilots, aerodynamics. Was Assistant Research Director for leading hi-fi manufacturer. Seeking management opportunity in New York metropolitan area.

**896. Contract or Project Administrator**—17 years' experience in aircraft and engine industries; 3 years on General Manager's staff, 4 years in engineering research and development contract areas. Prefer western New York or Pennsylvania or eastern Ohio location with small, aggressive manufacturer or research group. Presently employed by a major U.S. corporation. Age 34.

**895. Engineer**—Age 35. B.S. (M.E.) and graduate work in M.E. Employed as a General Engineer GS-12. Nature of employment: weapon system studies for past 3 years. Previous 4½ years employed in evaluation of Naval ordnance. Can qualify as an aeronautical, mechanical, or general engineer. Would like a career appointment to a GS-13 position in the Washington, D.C., area. A completed Form 57 will be sent on request.

**893. Executive or Assistant to Executive**—Age 34. B.S. in Ae.E.; M.B.A. in Industrial Management. Objective—to capitalize on past general experience in a management capacity with growth company. Experienced in administrative engineering, Air Force procurement, production and contract administration, reliability engineering, establishment of company policies and procedures, customer liaison, industrial relations, and sales. Presently employed—income $13,500. Detailed résumé and references furnished to company officers.

**892. Aeronautical Engineer**—Age 52. Extensive experience in aviation in industry, including 7 years as stress engineer and 5 years as chief of structural engineering section for USAF overseas which specialized in aircraft structural strength problems, such as repair, modification, aircraft damage evaluation, fire damage, corrosion, accident investigations, etc. In addition, spent several years with a large aircraft company supervising the structural strength aspects of aircraft structural repair, shop contact engineer and salvage engineer. Available immediately. Prefers position overseas but will accept position in U.S. either with the Government or in private industry. Willing to travel. Detailed résumé forwarded on request.




# Consult your 1958 EDITION

## AERONAUTICAL ENGINEERING CATALOG

For Names — Current Addresses — Complete Product Descriptions of all principal manufacturers of Missile, Rocket, Air and Spacecraft Components and Materials.

**▶ Specific product data of these leading companies are filed in the 1958 AERONAUTICAL ENGINEERING CATALOG.**

AC Electronics Div., General Motors Corp.
Adel Precision Products, Div. of General Metals Corp.
Advanced Research Associates, Inc.
Aerojet-General Corp., Turbo-Machinery Div.
Aeronautical Equipment Research Corp.
Aeroquip Corp.
Aircraft Radio Corp.
The American Brass Co.
American Felt Co.
Amphenol Electronics Corp.
Avco Manufacturing Corp.
Bendix Aviation Corp., Bendix Products Div.
Century Controls Corp.
Chain Belt Co.
Chandler-Evans
Cherry Rivet Div., Townsend Co.
Cleveland Pneumatic Tool Co.
Coleman Engineering Co., Inc.
Crosley Div., Avco Manufacturing Corp.
Davis Aircraft Products, Inc.
Delavan Manufacturing Co.
Eastern Industries, Inc.
Thomas A. Edison Industries, Instrument Div.
Elastic Stop Nut Corp. of America
Electrical Engineering & Manufacturing Corp.
Federal Telecommunication Laboratories
Flexonics Corp., Aircraft Div.
Ford Instrument Co.
General Electric Co., X-Ray Dept.
Hartwell Aviation Supply Co.
Houdaille Industries, Inc., Buffalo Hydraulics Div.
International Aerocoustics Corp.
International Telephone & Telegraph Corp.
Jack & Heintz, Inc.
Johns-Manville
Joy Manufacturing Co.
Kearfott Co., Inc.
Kelsey-Hayes Co.
Klincher Locknut Corp.
Lavelle Aircraft Corp.
Lewis Engineering Co., The
Linde Co., Div. of Union Carbide Corp.
Link-Belt Co.
Marman Div., Aeroquip Corp.
Minnesota Mining & Manufacturing Co., Adhesives, Coatings & Seaters Div.
National Water Lift Div., Cleveland Pneumatic Tool Co.
The New York Air Brake Co.
Pheoll Manufacturing Co.
Pioneer Parachute Co., Inc.
Revere Corp. of America
M. H. Rhodes, Inc.
Rohr Aircraft Corp.
Safe Flight Instrument Corp.
Shafer Bearing Div., Chain Belt Co.
Sierra Engineering Co.
Simmonds Aerocessories, Inc.
Simmons Fastener Corp.
Solar Aircraft Co.
Southwest Products Co.
Standard Pressed Steel Co.
Stanley Aviation Corp.
M. Steinthal & Co., Inc.
F. W. Stewart Corp.
Stratoflex, Inc.
Swedlow Plastics Co.
Technical Development Co.
Townsend Co.
Union Carbide Corp.
U. S. Industries, Inc.
United States Steel Corp.
Vickers, Inc.
Voi-Shan Manufacturing Co.
The Weatherhead Co., Aviation Div.
Western Design & Manufacturing Corp.
Western Sky Industries
Weston Electrical Instrument Corp.
S. S. White Industrial Div.
Wittek Manufacturing Co.
Yardney Electric Corp.

NOTE: Effective with the 1959 Edition, the Catalog will be renamed "AERO/SPACE ENGINEERING CATALOG"

*IAS MEMBERS—Ordered your copy yet?—One copy free to members.*
*Nonmember price $7.50*

**AERONAUTICAL ENGINEERING CATALOG**

An Official Publication

**INSTITUTE OF THE AERONAUTICAL SCIENCES**

**2 East 64th Street** **New York 21, N.Y.**



XUM

# A word about our Advertisers

The many companies whose advertising appears in this issue are interested in you and your work. They are anxious to let you know what they are doing to help you solve research and design problems in missile, rocket, air, and spacecraft projects.

AERO/SPACE ENGINEERING's advertising pages keep you posted on new and improved materials, components, services, and supplies useful to your professional work.

To request more information on any product or service advertised, may we suggest you use the green self-addressed reply cards inserted at the end of this issue. No postage is needed. Our staff will be glad to forward all requests to the proper companies for direct reply to you.

AERO/SPACE ENGINEERING
2 E. 64th St., New York 21, N.Y.

# Index to Advertisers


Aeronutronic Systems, Inc. ..... 123
Aero/Space Engineering ..... inside back cover, 87
AiResearch Mfg. Divs., The Garrett Corp. ..... 91
Allison Div., General Motors Corp. ..... 69
American Institute of Physics ..... 119
Applied Physics Laboratory, Johns Hopkins University, The ..... 93
Arma, A Div. of American Bosch Arma Corp. ..... 14

B & K Instruments, Inc. ..... 59

★Chain Belt Co., Shafer Bearing Div. ..... 61
★Chandler-Evans ..... 16
Christie Electric Corp. ..... 77
Continental Aviation & Engineering Corp. ..... 64
Convair, A Div. of General Dynamics Corp. ..... back cover
Cornell Aeronautical Laboratories, Inc. ..... 122

Garrett Corp., The, AiResearch Mfg. Divs. ..... 91
General Dynamics Corp., Convair Div. ..... back cover
Stromberg-Carlson Co. Div. ..... 84, 85
General Electric Co., Missile & Space Vehicle Dept. ..... 122
General Motors Corp.
Allison Div. ..... 69
Harrison Radiator Div. ..... 4
General Radio Co. ..... 62
Gits Bros. Mfg. Co. ..... 89
B. F. Goodrich Co., The ..... 72
Goodyear Aircraft Corp. ..... 1

Harrison Radiator Div., General Motors Corp. ..... 4
Hughes Aircraft Corp., Communications Div. ..... 71

International Telephone & Telegraph Corp., Industrial Products Div. ..... 92

Janitrol Aircraft Div., Surface Combustion Corp. ..... 83
Johns Hopkins University, The, Applied Physics Laboratory ..... 93

Lamb Electric Co., The ..... 112
Lockheed Aircraft Corp., Missile Systems Div. ..... 6, 7, 66, 67

Marquardt Aircraft Co. ..... 114

National Aeronautics & Space Administration ..... 116
Norden Div., United Aircraft Corp. ..... 12

Pennsylvania State University, The, Ordnance Research Laboratory ..... 114

Radio Corp. of America ..... 118
Republic Aviation Corp. ..... 79
Resistoflex Corp. ..... 18
★Rohr Aircraft Corp. ..... inside front cover

Sargent Engineering Corp. ..... 8
★Shafer Bearing Div. Chain Belt Co. ..... 61
Space Technology Laboratories, Inc. ..... 75
J. S. Staedtler, Inc. ..... 11
Stromberg-Carlson Co., Div. of General Dynamics Corp. ..... 84, 85
Surface Combustion Corp., Janitrol Aircraft Div. ..... 83

Taber Instrument Corp. ..... 65

United Aircraft Corp., Norden Div. ..... 12
United Aircraft Products, Inc. ..... 81

Wyman-Gordon Co. ..... 126


**★ Specifications and further information on the missile, rocket, and aircraft products of these companies will be found in the 1958 AERONAUTICAL ENGINEERING CATALOG**

The only publication devoted exclusively to the aero/space industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft and missile parts and materials. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading manufacturers of missiles, rockets, aircraft and spacecraft, and their related components; Government Agencies; Research Organizations; etc.

*Published Annually by*

INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street • New York 21, N.Y.

# the spirit of '76 . . .

THE SPIRIT OF '76 . . . exemplifying strength —dependability—determination to move forward through the years.

Wyman-Gordon enters its 76th year still forging ahead with new forging techniques—still meeting the challenge of the seemingly impossible in this age of power and speed on the ground—in the air—and in outer space.

It is a far cry from the modest beginning in 1883 to the forging industry's most modern testing and research facilities in the extensive laboratories of Wyman-Gordon today—assurance of the ultimate in forging quality.

From the high wheel bicycle through the "horseless carriage" days to the "Mach era" of aircraft and space vehicles, Wyman-Gordon has marched under the standard of "The Greatest Name in Forging."

## WYMAN-GORDON COMPANY

*Established 1883*

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN

## New Products and Product Literature of interest to the Profession.

▼▼▼▼

IMPORTANT NOTE: To obtain information on products listed, please use the attached postage-paid cards. Simply write in the key number assigned to each item. Key numbers are in *italics* immediately following the title; i.e. (*M-1*), (*P3*), (*R12*), etc. Use a *single card* to list all items below of interest to you.

### AIRCRAFT & MISSILE MATERIALS & PROCESSES

**Alloy 7079 Thick Aluminum Plate.** (*M-1*) Ranges in thickness from 3 to 6 in.; chief advantage is high suitability for machining into longer, wider aircraft parts, of uniform thickness, than can be fashioned from large hand forgings. *Aluminum Co. of America*, 1501 Alcoa Bldg., Pittsburgh 19, Pa.

**404 Weldable Alloy for Highly Stressed Parts.** (*M-2*) Meets the need for a metal used for highly stressed parts at temperatures up to 1,050°F. where joining is a problem; designed to be free from weld cracking without preheating or postheating. *The Carpenter Steel Co.*, Reading, Pa.

**Silastic RTV® 502.** (*M-3*) This new silicone material is an easy-to-apply liquid which vulcanizes to a rubber in only 30 min.; retains flexibility from −70° to +500°F.; has good electrical insulating properties. *Dow Corning Corp.*, Midland, Mich.

**"Eccocoat" Surface Coatings.** (*M-4*) 12-page brochure contains data describing coatings used for component protection and ruggedization, printed circuit boards, hermetic sealing of assemblies, etc. *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass.

**Heat-Resistant Quartz Thread.** (*M-5*) Claimed to be one of the most heat-resistant materials available for its weight; in the form of cloth, may be used to reinforce plastics used in aircraft and missiles to improve strength-to-weight ratios and increase potential payload of space vehicles. *General Electric Co.*, Lamp Glass Dept., Nela Park, Cleveland 12, Ohio.

**Cryogenic Insulations.** (*M-6*) A series of superinsulations claimed to be up to 26 times more efficient than standard vacuum insulations; permits building liquid oxygen storage tanks for missile stands that will hold the volatile liquid for months and even years with little loss. *Linde Co.*, A Div. of Union Carbide Corp., 420 Lexington Ave., New York 17, N.Y.

**Plasma Arc Torch.** (*M-7*) A radically new method for fabricating shapes and applying coatings that will withstand temperatures above 5,000°F. using a device which harnesses temperatures up to 30,000°. *Linde Co.*, A Div. of Union Carbide Corp., 300 Madison Ave., New York 17, N.Y.

**New Titanium Alloys.** (*M-8*) Four new alloys—MST-2½-AL-16V, MST-821, MST-185, and MST-3AL-2½V—designed primarily for use in the aircraft and missile industry. *Mallory-Sharon Metals Corp.*, Niles, Ohio.

**Large-Scale Metal Forming by Explosives.** (*M-9*) This new method involves the use of an explosive charge, a shock-transmitting medium, and the object to be formed all contained within a "constraining die"; claimed to achieve an increase of up to 30% in the strength of the metal being formed. *Propellex Div.*, Chromalloy Corp., Edwardsville, Ill.

**"Heat-Rem H-170" Heat-Resistant Paint.** (*M-10*) Claimed to withstand temperatures up to 1,700°F.; makes possible effective coating of many metal surfaces formerly regarded as "unpaintable" because of temperature limitations. *Speco, Inc.*, 7308 Associate Ave., Cleveland 9, Ohio.

**Grade G-5 Laminated Plastic.** (*M-11*) Technical Bulletin 4.5.1 describes a material characterized by high tensile and flexural strengths plus high arc and flame resistance. *Taylor Fibre Co.*, Norristown, Pa.

**USE THESE CONVENIENT, SELF-ADDRESSED, POSTAGE-PAID CARDS TO REQUEST ADDITIONAL INFORMATION ON ANY ITEMS, ARTICLES, OR ADVERTISEMENTS IN THIS ISSUE.**




*Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.*

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

BUFFALO
DEPARTMENT OF TECHNOLOGY

NAME..... POSITION.....
COMPANY.....
STREET.....
CITY & STATE.....

AERO/SPACE ENGINEERING
an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES
(Professional Engineering Society for the Aero/Space Industry)
2 E. 64th St., New York 21, N.Y.

Request for Information

*Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.*

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

BUFFALO
DEPARTMENT OF TECHNOLOGY

NAME..... POSITION.....
COMPANY.....
STREET.....
CITY & STATE.....

AERO/SPACE ENGINEERING
an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES
(Professional Engineering Society for the Aero/Space Industry)
2 E. 64th St., New York 21, N.Y.

Request for Information

**"Hydrostrip" High-Pressure Seal.** (*P-1*) For removable tank openings and pressurized access doors in missiles and rockets; pressure range is from 0 to 3,000 psi, in either direction. *A. P. M. Co.*, 252 Hawthorne Ave., Yonkers, N.Y.

**Aircraft Hardware Manual.** (*P-2*) The first three sections of this new manual are now available; when fully complete, it will contain specifications and detailed drawings of over 700 items of aircraft hardware. *Adams-Rite Manufacturing Co.*, 540 W. Chevy Chase Dr., Glendale, Calif.

**360° Rotation Joints.** (*P-3*) For use wherever ram or bleed air must be transferred between hinged or rotated sections; can handle pressures up to 390 psi and temperatures from −55° to +735°F. *Aeroquip Corp.*, Jackson, Mich.

**"Aerobelt" Aircraft Seat Belt.** (*P-4*) Features an inertia reel lock permitting considerable freedom under normal flight conditions; imposition of any sudden load, however, causes the reel to lock almost instantly. *The Aerotherm Corp.*, Bantam, Conn.

**"OAR" Automatic Focusing System.** (*P-5*) Potential applications for this system include simple ranging or distance-determining devices, anticollision equipment, and automatic ground-elevation indicators for terrain and strip cameras; operates by continuously measuring and interpreting light or heat concentrations along the focal axis of a system of lenses which gather and focus radiant energy. *Comapco, Inc.*, 17071 Ventura Blvd., Encino, Calif.

**"Con-P-Pak" Thermocouples.** (*P-6*) Conductors are encased in specially processed ceramics and surrounded by chemically clean metal sheaths; for temperatures ranging from −300° to over 1,600°F. *Continental Sensing, Inc.*, 1950 N. Ruby St., Melrose Park, Ill.

**Rocket & Missile Systems.** (*P-7*) 36-page brochure details the company's capabilities in propulsion, electronics, telemetry, instrumentation, ground support, upper atmospheric research, target systems, and related activities. *Cooper Development Corp.*, 2626 S. Peck Rd., Monrovia, Calif.

**New Ski for Small Aircraft.** (*P-8*) A combination wheel-ski landing gear operable from the cockpit; transfer to ski or wheels can be made whenever desired—in the air, while taxiing, or while parked. *Fli-Lite Corp.*, Roseau, Minn.

**Missile Servicing Nozzle & Adapter.** (*P-9*) This lightweight unit for propellants and other fluids features a high flow rate and minimum pressure drop; designed for rapid servicing of missiles in temperatures from −320° to +160°F. *Flight Refueling Inc.*, Friendship International Airport, Box 1701, Baltimore 3, Md.

**No. 1958 Wind-Tip Identification Lamp.** (*P-10*) A 150-watt, 28-volt tubular quartz lamp 2¹/₄ in. long by 1/2 in. in diameter; rated life is 300 hours; designed especially for thin-winged supersonic aircraft. *General Electric Co.*, Nela Park, Cleveland 12, Ohio.

**Ungrounded Piezoelectric Accelerometers.** (*P-11*) 30 new units are designed to eliminate the problems of circulating ground currents. *Gulton Industries, Inc.*, 212 Durham Ave., Metuchen, N.J.

**Model 4087 "Nine-in-One" Flight Indicator.** (*P-12*) 4-page brochure describes instrument displaying course selection, reciprocal course heading, "to-from" indication, lateral course deviation, glide slope indication, glide slope flag alarm, localizer indicator, localizer flag alarm, and heading changes. *LearCal Div.*, Lear, Inc., 3171 S. Bundy Dr., Santa Monica, Calif.

**Model P-832B Ethylene Oxide Pump.** (*P-13*) Used in an auxiliary power package for missile applications, this positive displacement, rotary, spur gear pump incorporates a cartridge construction. *Lear-Romec Div.*, Lear, Inc., Elyria, Ohio.

**Lightweight Missile Regulators.** (*P-14*) Designed for use in rocket and missile engines; a unique feedback system senses fuel tank pressure and automatically changes the regulator delivery pressure to maintain a constant pressure in the fuel tank. *Linde Co.*, Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y.

**MC 2660 4-Port Control Valve.** (*P-15*) A four-way, three-position, manually operated valve; intended primarily for operation with air at 600 psi throughout a temperature range of −65° to +160°F. with intermittent exposure to +260°F. *M. C. Mfg. Co.*, Lake Orion, Mich.

**Lightweight Thermal-Heaters.** (*P-16*) Typical of these new units is a 40-watt circular heater weighing less than 1/4 oz. (including 12-in. leads); flexible construction permits application to flat or curved surfaces. *Minco Products, Inc.*, 740 Washington Ave. N., Minneapolis 1, Minn.

**Aircraft Ground Power Units.** (*P-17*) New brochure describes complete line of energizers for supporting modern aircraft while on the ground; includes a check list showing each make of airplane's power requirements. *Motor Generator Corp.*, Box DM-88, Troy, Ohio.

**Graphite Rocket Exhaust Nozzles.** (*P-18*) Capable of withstanding tremendous thermal shock, yet can be machined readily to the extremely close tolerances required for the tapered throat; erosion and wear during the firing time is held to extremely close limits. *Stackpole Carbon Co.*, St. Marys, Pa.

**"Capabilities & Facilities" Brochure.** (*P-19*) 36-page booklet describes company's equipment and work in the development of aircraft and missile electric and hydraulic power supply systems. *Sundstrand Turbo*, A Div. of Sundstrand Machine Tool, Pacoima, Calif.

**"Finger-Flexible" Aircraft Hose.** (*P-20*) For high-temperature aircraft application; this extremely flexible Springfield "400" hose is available in diameters from 3/4 in. to 2 in. with a minimum bend radius of 3¹/₂ times the equivalent tube size. *Titeflex Inc.*, Hendee St., Springfield 4, Mass.




BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

**SK1991 High-Altitude Blower Unit.** (*P-21*) For ventilating and cooling aircraft enclosures and electronic equipment; air delivery is 500 cfm at a static pressure of 2.4 in. of water at 65,000 ft. *The Torrington Mfg. Co.*, Air Impeller Div., Torrington, Conn.

**"Truarc" Retaining Ring Catalog.** (*P-22*) New 24-page catalog No. RR-10-58 contains complete descriptions and illustrations of all currently available retaining rings, pliers, and accessory tools. *Waldes Kohinoor, Inc.*, 47-16 Austel Pl., Long Island City 1, N.Y.

**MA-1 Pitot Static Tube.** (*P-23*) Bulletin #581 describes device used to supply total and static pressure for flight instruments on subsonic and supersonic aircraft and missiles to Mach 3. *Waste King Corp.*, Technical Products Div., 4000 Pacific Blvd., Los Angeles, Calif.

## ELECTRONIC & ELECTRICAL EQUIPMENT

**Signal Comparator Monitors Missile "Readiness."** (*E-1*) Can monitor any required number of signal channels simultaneously; designed for either airborne or ground checkout applications. *Avien, Inc.*, 58-15 Northern Blvd., Woodside 77, N.Y.

**"Minified" Analog-to-Digital Millivolt Meter Indicator.** (*E-2*) This servo-driven potentiometric unit has a laboratory accuracy of 0.1%; features digital readout from 144 in. tape-slidewire, programing contacts for dependent functions, with retransmitting slidewire for remote indication, recording, or telemetering. *B & H Instrument Co., Inc.* 3479 W. Vickery Blvd., Ft. Worth 7, Tex.

**Model 81 Digital Voltmeter.** (*E-3*) An all electronic transistorized unit; accuracy and resolution of this new unit is 0.015% over the three automatically switched ranges of ±10, ±100, and ±1,000 volts d.c. *Beckman Systems Div.*, 325 N. Muller Ave., Anaheim, Calif.

**Aluminum RF Cannon Plugs.** (*E-4*) Catalog ALRF-1 describes a new line of lightweight RF plugs, the first to utilize aluminum shells. *Cannon Electric Co.*, 3208 Humboldt St., Los Angeles 31, Calif.

**Environment-Resisting Miniature Plugs.** (*E-5*) 12-page catalog KM-1 details a new series used in airborne applications where extremes of humidity and barometric pressure are experienced. *Cannon Electric Co.*, 3208 Humboldt St., Los Angeles 31, Calif.

**Inertially Damped Servomotor.** (*E-6*) This compact unit is said to be electrically equivalent to the lead-lag network commonly used in servomechanism applications; operates to 150°C. *Eastern Air Devices, Inc.*, 377 Central Ave., Dover, N.H.

**"Ceramatemp" Insulated Wire.** (*E-7*) 8-page technical bulletin gives data on a ready-to-use flexible ceramic-type wire rated for continuous operation at 1,000°F. *Hitemp Wires, Inc.*, 1200 Shames Dr., Westbury, N.Y.

**Model D-1000 28 Volt D.C. Motor.** (*E-8*) This 1.6-hp. unit is designed for rugged duty; features explosionproof construction; capable of withstanding continuous starting at rated load at 2-sec. intervals under severe inrush conditions. *Hoover Electric Co.*, Hangar 2, Port Columbus Airport, Columbus 19, Ohio.

**Ruggedized Silicon Solar Cells.** (*E-9*) Capable of converting 10% and higher of the radiant energy falling on their surface; provides an output of approximately 9 watts per sq.ft. of active cell area in bright sunlight. *International Rectifier Corp.*, 1521 E. Grand Ave., El Segundo, Calif.

**TPC-14 Transistorized Power Supply.** (*E-10*) Utilizes a novel bridge-transistor circuit to deliver 260 volts d.c. and 135 ma at over 80% efficiency with better than 5% regulation. *Southwestern Industrial Electronics Co.*, 10201 Westheimer, Houston, Tex.

**Model RS-5178 Miniature Solenoid.** (*E-11*) Features high-speed response; will operate with a 10-lb. load; stroke is 0.015 in. with the start of the motion occurring at a maximum of 6 millisec. and completed at less than 13 millisec. from closing circuit. *Telco Sales Div.*, Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif.

**Model C6N2DB Coaxial Switch.** (*E-12*) This small, 115-volt a-c actuator meets airborne specifications and will operate from 60-, 400-, 1,600-, and 2,400-cycle power sources. *Thompson Products, Inc.*, Tapco Group, 23555 Euclid Ave., Cleveland 17, Ohio.

## DRAFTING ROOM, PRODUCTION, & MISC. EQUIPMENT

**"Hairflex" Cushioning Material.** (*S-1*) For maximum product protection during shipping; endless shock and vibration cannot deteriorate this material. *Armour & Co.*, Alliance, Ohio.

**Alloy-Form Dies.** (*S-2*) Bulletin AFD-958 describes a complete line of dies for bending and forming the various alloy sheets and plates used in aircraft,

**USE THESE CONVENIENT, SELF-ADDRESSED, POSTAGE-PAID CARDS TO REQUEST ADDITIONAL INFORMATION ON ANY ITEMS, ARTICLES, OR ADVERTISEMENTS IN THIS ISSUE.**




Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME..... POSITION.....

COMPANY .....

STREET.....

CITY & STATE.....

AERO/SPACE ENGINEERING

an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES

(Professional Engineering Society for the Aero/Space Industry)

2 E. 64th St., New York 21, N.Y.

Request for Information

Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME..... POSITION.....

COMPANY .....

STREET.....

CITY & STATE.....

AERO/SPACE ENGINEERING

an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES

(Professional Engineering Society for the Aero/Space Industry)

2 E. 64th St., New York 21, N.Y.

Request for Information

missiles, rockets, and other fabrications. *Dreis & Krump Mfg. Co.*, 7400 S. Loomis Blvd., Chicago 36, Ill.

**Isometric Gear Guide.** (*S-3*) An underlay drawing aid with a rack and 21 spur gear faces having 6 to 48 simplified teeth in isometric projection. *Graphicraft*, P.O. Box 509, Westport, Conn.

**Miniature Drills Reamers & Endmills.** (*S-4*) 8-page catalog SB-302 covers the company's standard offerings in sizes as small as 0.024 in. diameter to meet numerous aircraft and missile production requirements. *Super Tool Co.*, 21650 Hoover Rd., Detroit 13, Mich.

## RESEARCH & TEST EQUIPMENT

**Research & Development Brochure.** (*R-1*) 10-page booklet describes company's work in aerodynamics, applied mechanics, aircraft operations, chemistry, electronics and instrumentation, and other fields relating to the physical and aeronautical sciences. *Allied Research Associates, Inc.*, 43 Leon St., Boston 15, Mass.

**Acoustic Noise Generator.** (*R-2*) A new electromechanical loudspeaker producing up to 166 db. of random noise; for acoustic noise testing of missile and rocket components and systems in the laboratory. *Avco Research & Advanced Development Div.*, 201 Lowell St., Wilmington, Mass.

**Hypervelocity Recording Cameras.** (*R-3*) Two bulletins describe a rotating mirror camera (speed 4 mm./microsec.) and a rotating drum camera (speed 0.19 mm./microsec) which record position-vs.-time relationships in wind tunnels, shock tubes, etc. *Avco Research & Advanced Development Div.*, 201 Lowell St., Wilmington, Mass.

**Model 2110 Spectrum Analyzer.** (*R-4*) Technical brochure BK2110 describes a device of the 1/3 octave type with center frequencies ranging from 40 to 32,000 cps. *B & K Instruments, Inc.*, 3044 W. 106th St., Cleveland, Ohio.

**"ASCAT" Analog Self-Checking Automatic Tester.** (*R-5*) Automatically tests the electrical, hydraulic, and pneumatic systems of guided missiles and airplanes in a fraction of the time normally required. *Bell Aircraft Corp.* P.O. Box 1, Buffalo 5, N.Y.

**Model 052 Multimode Test Turntable.** (*R-6*) For laboratory test and evaluation of inertial navigation equipment; the 26-in. diameter platform can accept loads up to 500 lbs.; may be used either as a servotable or a sidereal rate table. *J. W. Fecker, Inc.*, 6592 Hamilton Ave., Pittsburgh 6, Pa.

**Catalog on Process Instruments.** (*R-7*) 52-page catalog No. 2 covers indicators, transmitters, recorders, and controllers for flow, pressure, temperature, density, viscosity, and consistency. *Fischer & Porter Co.*, 941 Jacksonville Rd., Hatboro, Pa.

**Remote Handling of Radioactive Materials.** (*R-8*) 20-page booklet covers a complete line of remotely controlled handling devices of use in nuclear research. *General Mills, Inc.*, Nuclear Equipment Dept., 1620 Central Ave., Minneapolis 13, Minn.

**Type B-731A Vibration Meter.** (*R-9*) Offers a new method of measuring distance and vibration; a noncontacting probe, connected to a 50-kc. oscillator and suitable amplifying equipment, is brought into proximity with the object under test; the capacitance so formed is interpreted in terms of distance and peak-to-peak vibration; both quantities are displayed on direct-reading meters. *Wayne Kerr Corp.*, P.O. Box 801, Philadelphia 5, Pa.

**"Systems Silencing."** (*R-10*) 15-page brochure covers the various types of sound control devices available to the aerospace industry; included are sound-treated test cells and portable and semiportable silencers. *Koppers Co., Inc.*, 200 Scott St., Baltimore 3, Md.

**Model Z-81 Zone Melting Apparatus.** (*R-11*) Combines automatic control with laboratory precision; produces high-purity metals for semiconductor applications. *Materials Research Corp.*, 47 Buena Vista Ave., Yonkers, N.Y.

**Model PE521-1 Black Body Reference Standard.** (*R-12*) This device provides an accurately adjustable source of infrared radiation. *Perkin-Elmer Corp.*, Norwalk, Conn.

**Igniter Volt-Ohmmeter for Missile Testing.** (*R-13*) Precludes misfiring of rockets and detonators; capable of measuring continuity, resistance, and stray d.c. voltage encountered in extremely sensitive electrical circuits. *Pesco Products Div.*, Borg-Warner Corp., Bedford, Ohio.

**Model H Servoscope®.** (*R-14*) For analysis of servosystems; measures phase, transient response, and gain; covers frequency ranges 0.1 to 2.0 cps and 1.0 to 20 cps. *Servo Corp. of America*, 20-20 Jericho Turnpike, New Hyde Park, L.I., N.Y.

**Model 60B Hot-Wire Anemometer.** (*R-15*) This instrument measures the velocity of an air stream, making use of the ability of the stream to absorb heat from an electrically heated thin wire filament; useful for studies of air flow in jet-engine components. *Shapiro & Edwards*, Electronic Instruments, 1130 Mission St., S. Pasadena, Calif.

**"SEE" Sperry Echo Enhancer.** (*R-16*) A unique electronic system that "beefs up" tiny radar pictures; makes possible use of small, relatively inexpensive target missiles and drone aircraft to simulate attacks by large enemy bombers. *Sperry Gyroscope Co.*, Div. of Sperry Rand Corp., Great Neck, N.Y.

**2-Axis Low-Threshold, High-Response Flight Simulator.** (*R-17*) Enables accurate testing of airborne electronic components over a full range of flight patterns; special design makes possible control of a wide range of rates and amplitudes from 0.004° to 240° and from 0.01 to 30 cps about either axis. *Task Corp.*, 1009 E. Vermont Ave., Anaheim, Calif.




BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.
DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.
DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY